WESTERN SYDNEY UNIVERSITY

The Effect of Rural-to-Urban Migration on Risk Factors of Cardiovascular Diseases in Bangladesh

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Dedication

To my beloved parents

Fatima Begum and Reazuddin Ahmed

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Statement of Authentication

This thesis is submitted in fulfillment of the requirements of the degree of Doctor of Philosophy in the School of Science and Health at Western Sydney University. The work presented in this thesis is, to the best of my knowledge and belief, original except as acknowledged in the text. I hereby declare that I have not previously submitted this material, either in full or in part, for a degree at this or in any other institution.

[redacted]

Shirin Jahan Mumu
September 2018

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Abbreviations

ADL	Activities of Daily Living
BAT	Brown adipose tissue
BBS	Bangladesh Bureau of Statistics
BDHS	Bangladesh Demographic and Health Survey
BMI	Body Mass Index
BP	Blood pressure
BUHS	Bangladesh University of Health Sciences
Ca	Calcium
CBC	Complete blood count
CHD	Coronary heart disease
CHO	Carbohydrate
CMS	Census and Mapping of Slums
CRP	C-reactive protein
CVD	Cardiovascular diseases
DALY	Disability adjusted life years
DBP	Diastolic blood pressure
FBG	Fasting blood glucose
FCBG	Fasting capillary blood glucose
FCT	Food Composition Table
FFQ	food frequency questionnaire
GBD	Global burden of disease
GLMM	Generalised linear mixed effect models
GPAQ	Global Physical Activity Questionnaire
HDL	High density lipoprotein
HH	Household
HIES	Household (HH) Income & Expenditure Survey
HOMA	Homeostatsis Model Assessment
Ht	Height
HTN	Hypertension
IGT	Impaired Glucose Tolerance
IHD	Ischemic Heart Disease

IMS	Indian Migration Study
IMS-PAQ	Indian Migration Study Physical Activity Questionnaire
IPAQ	International Physical Activity Questionnaire
IQR	Interquartile Range
LDL	Low density lipoprotein
LMICs	Low- and middle-income countries
LTPA	Leisure-time physical activity
mcg	microgram
MET	Metabolic Equivalent Tasks
Mg	Magnesium
MI	Myocardial infraction
MLTPA	Minnesota Leisure Time Physical Activity
Mmol/l	Millimoles per litre
MS	Metabolic Syndrome
MVPA	Moderate-to-vigorous physical activities
NCDs	Non-communicable diseases
NIPORT	National Institute of Population Research and Training
OPD	Out Patient Department
OR	Odds Ratio
PA	Physical activity
PAL	Physical Activity Level
PAR	Population-attributable risk
PYPAQ	Past year physical activity questionnaire
PUFA	Poly unsaturated fatty acid
PSUs	primary sampling units
SAs	South Asians
SBP	Systolic blood pressure
SDI	Sociodemographic index
SES	Socioeconomic status
SFTs	Skinfold thickness
SR	Systematic review
SRQ	Self-Reporting Questionnaire

List of Publications

Journal articles

- **Mumu SJ**, Ali L, Barnett A, Merom D. Validity of the global physical activity questionnaire (GPAQ) in Bangladesh. BMC Public Health 2017; 17:650: https://doi.org/10.1186/s12889-017-4666-0.

- **Mumu SJ**, Ali L, Fahey P, Rahman AKMF, Merom D. Seasonal variations in physical activity domains among rural and urban Bangladeshi using a culturally relevant Past-Year Physical Activity Questionnaire (PYPAQ). Journal of Environmental and Public Health. In press.

- **Mumu SJ**, Merom D, Ali L, Fahey P, Hossain I, Rahman AKMF, Allman-Farinelli. Adaptation and validation of existing food frequency questionnaire for cardiovascular disease to monitor dietary pattern in Bangladesh. Nutrition Journal. Under review.

Conference Papers

- **Mumu SJ**, AKM F Rahman, Ali L, Fahey D, Merom D. The effect of rural-to-urban migration on diabetes and its risk factors: a sibling-pair comparative study. Accepted for International Diabetes Federation Congress 2019, 2-6 December, Busan. *(Oral Poster presentation)*

- **Mumu SJ**, AKM F Rahman, Ali L, Fahey D, Merom D. The effect of internal migration on diabetes: a sib-comparative study. Presented in the 15th International Conference on Urban Health 2018, 27-30 November 2018, Kampala, Uganda. *(Oral presentation)*

- **Mumu SJ**, Ali L, Rahman AKMF, Merom D. Differences in physical activity among rural-to-urban migrant and non-migrant: the Bangladesh sibling-pair comparative study. 7th International Society for Physical Activity and Health (ISPAH) Conference, London, England, October 15-17, 2018. *(Oral presentation)*

- **Mumu SJ**, Merom D, Ali L. Validity of the Global Physical Activity Questionnaire (GPAQ) in rural and urban population: the case of Bangladesh. 21st IEA World Congress of Epidemiology (WCE 2017), Saitama, Japan, August 19-22, 2017. *(Oral presentation)*

- **Mumu SJ**, Merom D, Ali L. Criterion validity of the Global Physical Activity Questionnaire (GPAQ) among urban and rural residents in Bangladesh. 6th International Society for Physical Activity and Health Congress, Bangkok, Thailand, November 16-19, 2016. *(Poster presentation)*

- **Mumu SJ**, Merom D, Fahey P. Rural-to-urban migration, overweight/obesity and the role of socio-demographic status in Bangladeshi women. World Diabetes Congress, Vancouver, Canada, November 30- December 04, 2015. *(Poster presentation)*

- **Mumu SJ**, Merom D. Effect of Rural-to-urban migration on overweight/obesity among Bangladeshi women. 12th SEA Regional Scientific Meeting of the International Epidemiological Association, Bangkok, Thailand, November 24-26, 2015. *(Oral presentation)*

Abstract

Background/Aim: Cardiovascular disease (CVD) has been emerging as an important public health problem in Bangladesh. The underlying cause of this epidemic is the increase in life expectancy accompanied by demographic transition and changing lifestyles as a result of urbanization. Bangladesh has been experiencing rapid urbanization for the past several decades, which is mostly driven by migration from rural area. Hence, it is vital to more fully understand the effect of rural-to-urban migration on CVD risk factors.

Methods: A secondary data analysis on nationally representative Urban Health Survey (UHS) data collected in Bangladesh followed by an empirical sibling-pair comparative study were conducted to identify the effect of migration on CVD risk factors, and the role of socioeconomic status (SES) and the impact of acculturation indicators on CVD risk. In the UHS study 27,792 participants were included in the analyses of whom 14,167 (M: 7278; W: 6889) were urban residents and 13,625 (M: 6413; W: 7212) were rural-to-urban migrants. The sibling-pair comparative study was conducted on 164 males migrated from Pirganj rural areas to Dhaka City and had been residing in Dhaka permanently for at least one year, and their rural siblings (total N =328). Participants were undergone interview particularly on diet, physical activity and other behavioural risk factors; measurement on anthropometric and blood pressure; and biochemical analysis of blood for blood glucose level and lipid profile. Besides, three validity studies on physical activity and dietary tools were conducted on 162 healthy participants of both genders aged 18-60 years from rural (n=97) and urban (n=65) areas to be used in sibling study as well as future CVD risk factors surveillance in Bangladesh.

Results: In the UHS study, the risk profile of migrant was lower than the risk profile of the urban group for most of the CVD risk factors (overweight and obesity, hypertension, diabetes, smoking) except bidi smoking and mental health disorder, which were higher in rural-to-urban migrants. The risk profile of CVD differed in men and women and women migrants were more vulnerable than any other groups in terms of metabolic risk factors and mental health disorders. Using the rural group as baseline, the sibling-pair comparative study demonstrates that the risk profile of migrant group was higher in all CVD risk factors. Migration was associated with an increased physical inactivity and reduced fruits and vegetable and poly unsaturated fatty acid (PUFA) intake in migrants, as compared with rural siblings, and this likely contributed to the higher levels of body mass index (BMI), skinfold thickness and lower high density lipoprotein (HDL) in migrants. The findings of both studies suggest that CVD risk factors increase with time spent in urban area, though the pattern and magnitude of these changes were not uniform and varied across risk factors and gender. In the UHS study, consistent increasing pattern of risk was observed with longer duration of urban stay in migrant men for obesity (OR=1.67), smoking (OR=1.67) and alcohol intake (OR=2.86). Among women, those with a longer period living in an urban area had 74% and 35% higher odds of being classified as overweight and obese, and with mental health disorder, respectively. In the sibling-pair comparative study, the strongest effects were seen with increasing duration of urban stay for the three primary outcome measures: low HDL (OR=6.53), inadequate fruit and vegetable intake (OR=4.83) and physical inactivity (OR=3.63). The UHS study demonstrated that the proportion of CVD risk factors among migrants were also varied by urban place of residence. Hypertension as well as overweight and obesity were more prevalent in non-slum than slum, whereas mental health disorder, cigarette and bidi smoking were

higher in slum and District Municipalities than non-slum. In the validity study, physical activity and dietary tools showed acceptable validity and therefore were used in the sibling study.

Conclusion: The overall findings of this thesis suggests that migration from rural to urban area is a risk for CVD. This risk increase with time spent in urban area due to acculturation and varied by urban place of residence. The studies give new insights into the increased CVD risk related with migration and urbanization in Bangladesh.

Chapter 1

Introduction

Chapter 1: Introduction

This chapter provides the background of the thesis, which focuses on the effect of rural-to-urban migration on risk factors of cardiovascular diseases (CVDs) in Bangladesh. CVDs are diseases affecting the heart, blood vessels and blood circulation. The most common form of heart disease is reduced blood supply to the heart, known as the coronary heart disease (CHD) or ischemic heart disease (IHD), due to narrowing or obstruction of the coronary arteries. These conditions often lead to myocardial infraction (MI), a condition that leaves a scar in the heart tissue leading to chronic morbidity and premature death. Another common manifestation of CVD is cerebrovascular disease or stroke, where the vessels that supply blood to the brain are interrupted. Due to the grave consequences of CVD, epidemiological research has tried to understand its causal web since the early 50s, in an attempt to reduce its incidence and improve treatment.

The chapter starts with an overview of the global burden of CVDs, placing the South Asia region as the most affected region. Second, the epidemiological evidence of the direct and indirect causes of CVD are discussed, highlighting modifiable lifestyle risk factors as major contributors to CVD burden. Third, the conceptual link between migration and CVD risk is presented by reviewing the epidemiological research on CVD risks that are associated with international and internal migration, including the acculturation framework to alternate lifestyles that may enhance or mitigate CVD risk. Fourth, focusing on Bangladesh, the above topics are discussed leading to the rationale of the thesis, its aims and structure.

1.1 Background

1.1.1 Global burden of cardiovascular diseases (CVD)

The global burden of disease has changed rapidly over the last few decades (1, 2). Worldwide the health burden has been shifting from communicable, maternal and perinatal causes to non-communicable diseases (NCDs) (2) which currently account for 71% of all deaths (3). Among NCDs, CVDs are the leading cause of mortality and morbidity. In 2008 it was estimated that the majority of the global deaths, approximately 17.3 million (30%), were attributed to CVD (4) and of these CVD deaths, around 80% were in low- and middle-income countries (LMICs) (5). The most prevalent CVDs are CHD and stroke. These conditions were the world's first and third causes of death in 2013 causing 247.9 deaths per 100,000 people, representing 84.5% of CVD deaths and 28.2% of all-cause mortality (6). Further, considering a measure that takes into account the years of life lost due to living with disability such as CVD, the disability adjusted life years (DALY), CVDs are responsible for 151,377 million DALYs, of which 62, 587 million are due to CHD and 46, 591 million to stroke (7).

CVD mortality greatly varies according to geographic region, gender, risk factors distribution, ethnicity and economics (2, 8, 9) [1]. Although in the 20th century, the burden of CVD was highest in high income countries, now the greatest burden of CVD occurs in LMICs (9). All low-middle income regions demonstrated a significant increase in CVD mortality during 2000 to 2012, whereas the proportion of CVD deaths fell significantly in high income countries in the same period by 5.5% (5.46–5.54) (2).

[1] For example, the death rates (per 100,000) of CHD vary 20 folds (35 in South Korea to 733 in Ukraine) in men and 30 folds (11 in France to 313 in Ukraine) in women (9. Wong ND. Epidemiological studies of CHD and the evolution of preventive cardiology. Nature Reviews Cardiology. 2014;11(5):276.) The highest rates of CVD-related deaths are in Eastern Europe, Central Asia, Middle East and North Africa.

Further, many people in LMICs die younger from CVD, often in their most productive years. This may be due to inequitable health care services which cannot respond to their needs. (7). While the CVD death rate declined with an increase in sociodemographic index (SDI) in many regions during 1990 to 2015, this was not the case for men in South Asia and for both genders in sub-Saharan Africa, despite improvement in SDI in these regions (10). Possible reasons may be the higher exposure to CVD risk factors and poor access to health care interventions (10).

Furthermore, in South Asia CVD presents more at younger ages than in other world regions. In South Asia, the age standardized mortality rate due to CVD (per 100,000) is the highest in India (306), followed by Bangladesh (283), Pakistan (274), Sri Lanka (271), Nepal (270) and Maldives (211) (11). The 52 countries study, including Bangladesh, India, Nepal, Pakistan, and Sri Lanka, found that the age of first CHD event (e.g., heart attack) was on average six years earlier (53 vs 59 years) for South Asian populations than those in the rest of the world (12). Thus, South Asian countries will suffer from tremendous loss in productivity of the workforce due to CVD mortality. There is no doubt that the burden of the CVD in South Asian countries is rising, nevertheless, there is a lack of large-scale, methodologically sound, epidemiological studies in these populations to estimate the true incidence of cardiovascular events. According to estimates of global burden of disease (GBD), sixty percent of world's CVD patients will be in India alone by the year 2020 (13, 14). In Pakistan, the percentage of proportional all-cause mortality due to CVD was 19% (15) in 2013 and the annual estimated incidence of stroke was $250/10^5$ persons in 2006 (13). A cross-sectional study conducted in Punjab, Pakistan showed that 17.5% (1109/6351) of the study population had a CVD (16). Another estimate from a cross-sectional analysis of Nepal suggested prevalence of CHD among thousand men aged 35 years or more was 5.7% (13). In Maldives and Sri Lanka, 11% and 20.1% of the total NCD-related deaths occurred due to CVDs, respectively (17). Thus, CVD is likely to become a major public health and clinical problem in South Asia like other developing countries.

1.1.2 Direct and indirect causes of the increase in CVD burden

Aging population is on the rise

CVDs are age related. Hence, the underlying direct cause of the CVD epidemic is the ageing population globally. Life expectancy at birth in both the more developed and less developed regions shows an upward trend. Globally, average life expectancy at birth increased from 48.1 years in 1950 to 70.5 years in 2017 for men and from 52.9 years in 1950 to 75.6 years in 2017 for women (18). It is projected that the number of people aged 65 or older will grow from an estimated 524 million in 2010 to nearly 1.5 billion in 2050 and most of the increase will happen in developing countries (19). In 2005-2010, life expectancy in LMICs was 67 years and is expected to reach 74.8 years in the next 40 years (20). As a result, in LMICs, the percentage of the population aged 60 or over is currently increasing at the fastest pace ever, from 9% of the population today to double (19%) by 2050, and triple by 2100 reaching 27% (20).

This demographic shifting will have a major impact on overall health care demands (1). The remarkable improvements in life expectancy have changed the leading causes of disease and death. As prevalence is a product of incidence and duration of disease, either increasing incidence or increasing duration of living with the disease can lead to increasing prevalence of CVD (21). The impact of an ageing population on CVD prevalence is largely due to a decrease in premature death, which manifests in an increase in the disability-related disease burden. In the U.S., Odden *et al.* showed that the large growth of the 65 years and older population in the U.S. will result in a substantial increase in CHD incidence, prevalence, mortality, and cost. Increases of 26% and 46% in CHD incidence and prevalence, respectively, are estimated from 2010 to 2040, mainly due to the U.S. ageing population (22). The GBD study from 2015 showed that CHD mortality sharply increased after age 40 years from an estimated 33 deaths per 100,000 in the 40-44 years old category to 1050 deaths per 100,000 in adults aged 75-79 years old. A similar pattern was observed for stroke (10).

CVD established risk factors and the impact of lifestyles

Decades of epidemiological research attempt to understand the aetiology of CVD and the factors that increase the risk of having CVD, apart from genetic predisposition. In the early 20th century Osler *et al* had already reported age, male gender, hypertension, and diabetes as CVD risk factors. After subsequent decades of experimental studies, the importance of diet and serum cholesterol have also been identified as risk factors. Further, ecological studies and the Framingham Heart Study have confirmed the significance of these risk factors. Smoking became evident as a risk factor of CVD after the 1950s (23).

Yousuf *et al.* made a distinction between the above risk factors of CVD as “proven” (risk factors those are causally linked) and “putative” (risk markers that primarily show association with CVD, but the cause and effect relationship is yet to be established). Causally linked risk factors are tobacco consumption, high level of low density lipoprotein (LDL), low level of high-density lipoprotein (HDL), high blood glucose level or diabetes, as well as high blood pressure (BP), physical inactivity, obesity and type of diet. The putative associated risk factors are low socioeconomic status (SES), elevated prothrombotic[2] factors, markers of inflammation, high homocysteine and lipoproteins, and psychological factors. Further, proven and putative factors are also interlinked for example, physical inactivity predisposes people to increased risk of obesity, high BP, high glucose and lipid levels but also varies by SES and/or psychological factors (24). This complex causal web suggests that CVD is preventable by modification of lifestyles.

Years of epidemiological research have found strong associations between biological, physiological and lifestyle factors that directly affect or predispose people to CVD. The INTERHEART study (a case-control study of risk factors for first MI in 52 countries worldwide and over 27,000 subjects) demonstrated that smoking, alcohol, physical inactivity, fruit and vegetable consumption, psychosocial factors, dyslipidemia, hypertension, diabetes, and abdominal obesity, are risk factors for MI in both genders and at all ages, worldwide (12). Next, the INTERSTROKE (a case-control study on the importance of conventional and emerging risk factors of stroke in 32 countries) also confirmed their observation that about 90% of the population-attributable risk (PAR)[3] of stroke is associated with ten potentially modifiable risk factors: smoking, diet, alcohol, physical activity (PA), psychosocial factors, hypertension, diabetes mellitus, abdominal obesity, cardiac causes, and apolipoproteins in each major region of the world, among ethnic groups, in men and women, and in all ages (25).

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[2] Any agent or condition that leads to thrombosis or obstruction of the vessel at its point of formation or travel to other areas of the body.

[3] A measure that estimates the potential reduction in the incidence of a specific disease that is attributed to a specific exposure to putative cause

According to the World Health Organization (WHO), CVDs are strongly associated and causally linked with four particular behaviours: tobacco use, physical inactivity, unhealthy diet and the harmful use of alcohol. These behaviours lead to four key metabolic/physiological changes: raised BP, overweight/obesity, hyperglycemia and hyperlipidemia (7). Other risk factors of CVDs are poverty, low educational status, advancing age, gender, genetic predisposition and psychological factors (stress, depression) (26). The WHO further describe epidemiological trends in the distribution of these risk factors; it has shown that most of the population has been experiencing an increased prevalence in both the behavioural and the underlying metabolic/physiological risk factors. Hypertension alone is the main risk factor for developing IHD, stroke, heart and renal failures and peripheral vascular diseases (27). The behavioural and metabolic risk factors often coexist in the same person and act synergistically to increase the individual's total risk of developing acute vascular events such as MI and stroke (7).

The global burden of established risk factors and their regional distribution

High systolic blood pressure (SBP) is a major risk factor of CVD globally and was estimated to have caused 10.4 million deaths in 2017, which was 22.8% higher than in 2007. This is more than CVD deaths related to elevated body mass index (BMI), fasting plasma glucose, and total cholesterol (28). Overweight and obesity is increasing in both developed and developing countries at an alarming rate. Globally, around 39% of adults aged more than 18 years (38% of men and 40% of women) were overweight in 2014 (29). High BMI contributed 148 million DALY in 2017, and this was 36.7% higher than in 2007 (28). Diabetes is another well-recognised risk factor of CVD and around 425 million people or 8.8% of adults aged 20-79 years are estimated to have diabetes globally. It is expected that the number will reach 629 million if this upward trend continues (30). The largest increases will take place in LMICs mainly due to modifiable risk factors, including physical inactivity and overweight and obesity (29, 30). The reasons behind the obesity and diabetes epidemic are increases in availability, accessibility, and affordability of energy-dense foods as well as reduced opportunities for physical activity (31). Thus, diet and physical activity each play an underlying role of all metabolic risk factors and CVDs. Insufficient physical activity increases risk of all-cause mortality by 20-30% and regular physical activity reduces the risk of IHD, stroke, diabetes and other NCDs (29). Around 3.2 million deaths happen each year because of insufficient activity and resulted in 69.3 million DALYs in 2010 (29). Low fruit and vegetable intake caused 99 million DALY for all causes in 2017 and of this amount 42.9 million was attributed solely to CHD (28). Another modifiable behavioural CVD risk factor is tobacco use which accounts for 7% of all female and 12% of all male deaths globally (29). The highest smoking prevalence is estimated around 31% in the European region, whereas the lowest is in the African region at 10% (4).

The leading risk factors vary substantially across regions, level of SDI, and gender throughout the world (8, 25, 28). For example, globally, high SBP ranked as the top risk factor in the GBD 2017 study (28). However, smoking was the leading risk factor for attributable DALYs for men and women in Western Europe, whereas smoking was the leading risk factor for men and high SBP was the leading risk factor for women in Eastern Europe. High alcohol intake, high BMI, and high fasting plasma glucose were found to be the leading risk factors for almost all countries in Latin America and the Caribbean in 2017. In East and Southeast Asia, smoking ranked as the leading risk factor for men, while for women high SBP was the top risk factor in East Asia and high FPG in Southeast Asia. High SBP, high fasting plasma glucose and smoking were the leading risk factors for countries in South Asia (28). Although the INTERSTROKE study and INTERHEART study established that exposure to unhealthy behaviour and conventional metabolic risk factors leads to a greater burden of CVD in South Asia, as in other regions, a number of novel CVD risk factors such as early childhood factors, adult metabolic abnormalities, household air pollution, and psychological and social factors have been identified among South Asians (SAs), and these risk factors need to be studied as potentially modifiable CVD risk factors (32).

Although the prevalence of CVD associated risk factors are increasing worldwide, these are largely modifiable. Most CVDs can be prevented by addressing risk factors such as tobacco use, unhealthy diet, obesity, physical inactivity, high BP, diabetes and raised lipids (33). The WHO estimated that 80% of CHD cases and stroke could be prevented by targeting the above risk factors (34). For instance, physical activity reduces the risk of CVD and type 2 diabetes by improving glucose metabolism, reducing body fat, and lowering BP (33).

1.1.3 Urbanisation - an indirect cause of increased CVD risk

A postulated indirect cause for the increase in CVD burden in the developing world is the process of rapid urbanisation and the globalisation of unhealthy behaviours such as, physical inactivity and diet-related factors which have impacted on weight status and tobacco and alcohol consumption (7, 19, 35). The increased 'dose' of risk factor exposure due to lifestyle changes and a longer period of exposure due to demographic changes (i.e., ageing population), lead to higher CVD risk (36).

Today more people live in urban than rural regions; in 2007 the global urban population surpassed the global rural population for the first time (37). It was estimated that 54.5% of the world's population lived in urban areas in 2016 and this figure is projected to be 60% by the year 2030. In 2016, there were 31 megacities (cities with 10 million inhabitants or more) globally, among them 24 were located in the least developed regions (38). Urbanisation is happening more rapidly in Africa and Asia than in other regions of the world (37).

Comparative studies: rural and urban living

Although urban living offers several opportunities and potential access to better healthcare, it also brings new and unique health challenges. Various studies on comparisons of urban and rural areas demonstrated higher rates of hypertension, obesity and adverse lipid profiles for urban individuals (39-42). Currently India is experiencing an epidemic of CVD attributed to lifestyle changes resulting from urbanisation (41). Similar results have been reported from China (43), Bangladesh (44) and Malaysia (45). In suburban and rural areas in India, Nepal, Pakistan, and South Korea, diabetes increased as a result of urbanisation (46-49). Most of the above studies that reported a difference in CVD risk factors between rural and urban regions were cross-sectional in design, except the study of South Korea where they examined the trend of changes in the diabetes-related mortality rate and socio-environmental factors during the last two decades. Although these cross-sectional studies suggest that the urban population is at higher risk of CVDs, it does not give insights as to how these risks were developed over time.

Urbanicity and CVD risk

Cities present a very different health environment than more sparsely populated rural areas. Urbanisation increases car ownership and transport which ultimately increases traffic congestion and air pollution; pressure on existing urban infrastructure such as transport, housing and health care because of a fast increase in population density; lack of green areas; creation of slums; and sewerage pollution (50). Urbanicity not only increased total calorie intake, the percentage of dietary fat, smoking, and decreased physical activity but also affected weight status, HbA1c levels and hypertension (50-52). A cross-sectional study conducted in Tamil Nadu, India that aimed to investigate the relationship between different levels of urbanicity (population size, population density, access to markets, communications, transport, education and health services) and modifiable risk factors of chronic disease, demonstrated that the age adjusted odds ratio of low physical activity, high BMI and high BP increased with the level of urbanicity (53).

Unplanned development in the urban areas has created an environment that is prohibitive and unsafe for physical activity (54). Three major environmental influences were linked to declines in physical activity in industrialised countries; shifting from work-related physical activity to sedentary work due to modern labour-saving technology; greater use of vehicles; and an increase in screen based leisure entertainment such as TVs and computers (55, 56). These trends hold true in developing countries albeit at a faster rate due to economic growth. People in developing countries are increasingly eating westernised foods with higher levels of total energy, saturated fat and salt and are being targeted by marketing for tobacco, alcohol and junk food, while availability of these products increases (57).

Concomitantly, the intake of whole grains and legumes has reduced (58). Urban areas may have high availability of fruits and vegetables, but prices determine access. A review on urbanisation and NCDs found evidence that urbanisation has been associated with risk factors for NCDs such as low physical activity, unhealthy diet, obesity and high BP within South East Asian countries (59). One of the reasons for rapid urbanisation worldwide is migration.

1.1.4 Migration and CVD risk

Human migration is an ancient phenomenon. Migration can be defined as 'a permanent or semi-permanent change in residence across administrative boundaries for a period greater than one year'(60). Migration can be international (across international borders) or internal (within national or territorial boundaries) (61). Although migration is widely studied from historical, social, economic, and cultural aspects, health and healthcare perspectives are understudied (62). However, health is one of the most important aspects of migration and migrants need not only social, economic but also health related support. Currently, migrants' health is a significant public health issue (62, 63) with growing evidence suggesting a relation between migration and CVD risk (64).

Conceptual framework to understand migration and CVD risk

The risk of CVDs has four common features which are related to pre- and post-migration stages: ethnicity and genetic predisposition, which is relevant to pre-migration risk; food habits, that is, pre-migration dietary habits and post-migration dietary acculturation; active or sedentary lifestyle; and stress, known as migration-related acculturative stress (65). Adding to these factors Odone et al argue that the circumstances of migration can contribute differentially to CVD risks; such as whether migration is voluntary or forced, domestic or international, permanent or temporary, from high or low SES and on top of biological characteristics interacting with the new environment (66). Figure 1.1 illustrates a framework suggested by Odone et al to explore CVD risks in migrants; it encompasses the crucial determinants pre-, during and post-migration as well as the notion that all of the above are influenced by upstream contextualised factors that are often out of the individual's control.

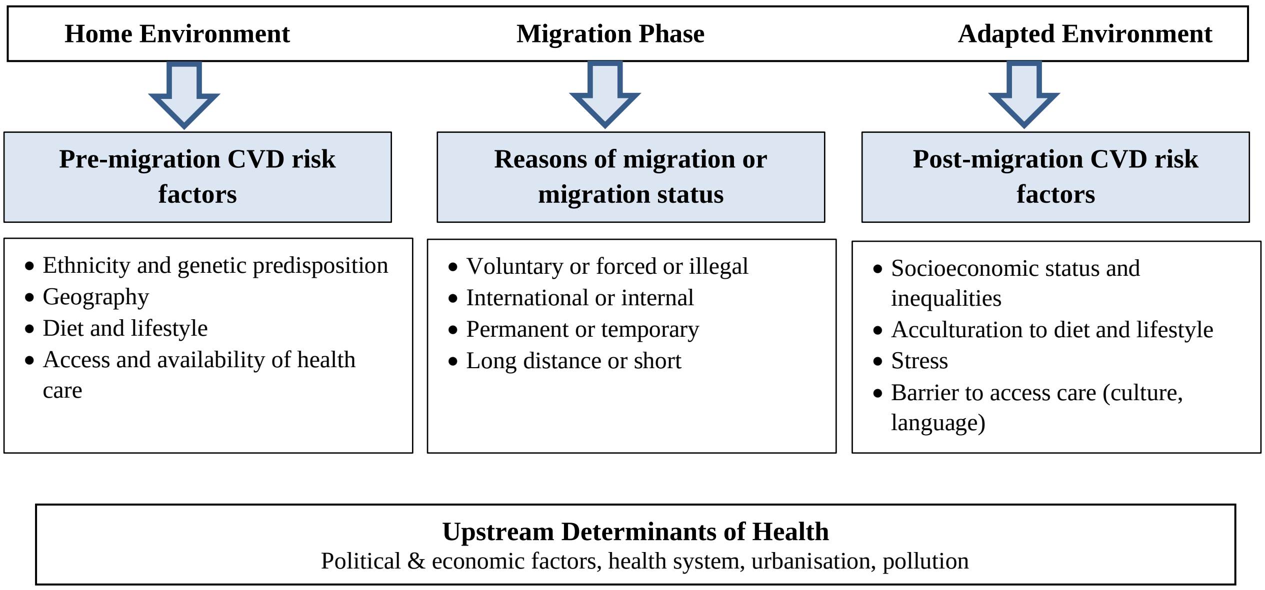

Figure 1. 1: A conceptual framework for understanding CVD risk among migrants[4]

[4] Adopted from: 66. Odone A, McKee C, McKee M. The impact of migration on cardiovascular diseases. International Journal of Cardiology. 2018;254:356-61.

1.1.4.1 International migration and CVD risk

Studying the effect of migration on CVD risk factors is useful in understanding the relative strength of association of different exposures in the country of origin and that in the host country (60). The two classic examples are the migrant study of Tokelau islanders who migrated to New Zealand following a hurricane in 1966; these islanders had a higher risk of diabetes and an increased rate of obesity after migration over the period 1968–1982 compared to non-migrants (67). Another study on Japanese first and second generation migrants living in Hawaii or in Los Angeles were found to have 2-3 times higher risk of diabetes than their ancestors living in Japan (68). These studies provide evidence of the adverse effect of adopting a Western way of life.

There are, however, some exceptions that are worth mentioning, for example, SAs in the UK, Europe and Canada showed lower rates of smoking, hypertension, and/or elevated cholesterol compared to Europeans. Nevertheless they had higher rates of CHD (8). Consistent reports from Canada showed that SAs have higher CVD prevalence than Caucasian and Chinese individuals (13, 69). High prevalence of impaired glucose tolerance (IGT), type 2 diabetes, central obesity, high triglycerides (TG), and low HDL cholesterol was observed among SA migrants in the UK and Canada (8, 65). Initially it was hypothesised that the high prevalence of these risk factors in SA migrants increased the risk of CVD, however, these metabolic risk factors are not sufficient to fully explain the observed excess CVD risk (70). An underlying factor that contributes to development of this disadvantageous metabolic phenotype is the presence of a lower amount of brown adipose tissue (BAT) in contrast to white adipose tissue (WAT) in South Asians. A low BAT volume results in lower energy expenditure, lower lipid oxidation and glucose uptake, as well as a high prevalence of inflammatory risk factors including visceral adipose tissue inflammation, endothelial dysfunction and high-density lipoprotein dysfunction (70). Hence, the higher risk of CVD among SA migrants is most likely due to the interactions between genetic susceptibility and environmental factors such as adopting lifestyle risk factors of urban areas.

Apart from SA migrants, the CVD trend differs hugely amongst migrants from other regions. For instance, in the Netherlands all-cause CVD mortality rate was 17% and 49% lower among Antillean/Aruban and Moroccan male migrants, respectively, and 13% higher among Surinamese male migrants compared to native Dutch (71). A recent systematic review and meta-analysis showed that although Chinese migrants had a much lower incidence of CHD compared to local whites and SAs, they had significantly higher short-term mortality after first diagnosis of CHD, features which were referred as the ‘Chinese Immigrant Paradox’ (72). Another paradox is known as the ‘Hispanic Paradox’ which has been described in Hispanic migrants in the U.S., who showed higher prevalence of CVD risk factors but lower CVD mortality compared to white Americans (65, 73).

Based on this evidence, it can be said that migrant studies could contribute to understanding the aetiology of the diseases where environment plays an important role. In addition to the role of environmental factors, migration studies may elucidate the relationship among genes, environment, society and culture which work together to accelerate morbidity and mortality attributable to CVD (60).

1.1.4.2 Rural-to-urban migration and CVD risk

Similar to international migration research, it is worthwhile to study rural-to-urban migrants and population of origin (rural) to understand the causal pathway of various disease outcomes. It is expected that urban migrants will acquire the high risk of the urban host population over time if the disease is largely environmentally determined (60), at the same time it is also expected that the changes may not be that dramatic as after all, rural-to-urban migrants can still share the language and culture of the country they grew up in.

Existing systematic review

A systematic review (SR) of rural-to-urban migration studies published in 2012 aimed to evaluate the effect of rural-to-urban within-country migration on CVD risk factors in LMICs (74). It was hypothesised that CVD risk profile would be lowest in rural, highest in urban and migrant was in between them. Literature was searched using PubMed-Medline, The Web of Science, and Scopus until December 31, 2010 and among 394 primary screened citations, 18 studies were selected for the qualitative synthesis. Most of the studies were done in Asian countries (six studies) followed by South America (five studies) and Africa (four studies). Among these 18 studies, 14 studies (78%) were cross-sectional, one was a retrospective cohort and three were prospective cohorts. Five studies compared the migrant group to both a rural and urban control group whereas ten studies compared the migrant to a rural group only. The remaining three studies compared migrants to urban residents. It is important to note that that only one study used a sibling-pair strategy while six studies traced a cohort of migrants.

The main finding of this SR indicated a gradient for most CVD risk factors, that is, a higher risk in urban migrants than rural dwellers but lower risk in urban migrants than urban dwellers. However, some CVD risk factors, such as SBP, diastolic blood pressure (DBP), HDL, fibrinogen and C-reactive protein (CRP) levels did not follow any gradient. This review was limited to a few metabolic risk factors of CVD. However, the effect of other metabolic risks as well as the antecedent lifestyles that are associated with these risk factors, such as smoking, diet and physical activity, were not quantified.

An update of literature

A subsequent search in the Medline database identified eight studies that were published after this SR to date (mid 2018). These studies were reviewed and are described in Annexure 1.1 (75-82). Among these studies, only one study was a cohort design (79) and the remaining seven studies were cross-sectional. Most of the studies were done in Asian countries (five studies) especially in India (four studies), followed by Africa (two studies), with one multi-country study conducted in China, Ghana, India, Mexico, Russia and South Africa. Five studies compared the migrant group to both a rural and urban control group, two studies compared migrant to only urban native (77, 80) and one study performed a comparison between recent migrants and settled migrants (75).

The findings of the recent studies support the gradient of the systematic review described earlier for overweight, obesity and BMI, which was lowest in rural dwellers, intermediate in migrants and highest in urban non-migrants. However, this pattern was not consistent for waist circumference, waist to hip ratio, total cholesterol, hypertension and diabetes. For example, four out of five studies showed higher hypertension rates for migrant than rural populations (76, 79, 80, 82) and one study reported no difference between the two (81).

More importantly, these recent studies included assessment of lifestyle risk factors. Inconsistency was observed for fruit and vegetable intake or fibre-diet, with three studies reporting three different findings. One study reported higher intake of fruits and vegetables among migrants and urban residents than rural (78) whereas the pooled analysis of the multi-country study showed lower intake among migrant than rural residents (81). The third study showed a low to high gradient of rural-migrant-urban for low fibre diet intake (76). Two studies (79, 81) reported physical activity; the weekly physical activity and occupational physical activity was the highest in the rural group compared to the migrant and urban groups. However, leisure time physical activity and active travel were significantly higher in migrant and urban groups in the pooled analysis from the multi-country study. In country level data, this pattern was mixed. Tobacco consumption was consistently found to be higher in rural groups than migrants in all studies.

Five studies examined whether duration of urban living was associated with an increase in CVD risk. Three studies reported that length of residence in urban areas was positively associated with waist circumference, waist to hip ratio, SBP and DBP. Two studies showed that recent rural-to-urban migrants had a greater risk of hypertension than non-migrant rural or urban dwellers, but it was not observed for medium term or established migrants.

Methodological challenges and inconsistencies of existing knowledge

One of the methodological challenges is to choose the appropriate study design for a migrant study. As noted, 21 out of 26 studies (81%) assessing the effect of migration on cardiometabolic risk were cross-sectional in design. This design cannot elucidate the temporal relationship between migration and CVD risk, for example, the rural-to-urban migrants can be a selected population with pre-migration risks rather than increasing their risk post-migration. The best study design is a follow up study where changes of behavioural and/or metabolic risk factors before migration and after migration can be measured over time. However, currently only four longitudinal studies are available (79, 83-85), and only one study from Tanzania had collected data before migration and then followed up migrants for one year after they settled in a new urban area. However, the study was of small sample size (n=209) which may limit the generalisation of the finding (83). The challenges of conducting a longitudinal study in LMICs are the logistical difficulties in identifying and tracing migrants where National Population Registry Systems do not exist or are of poor coverage. To overcome this, a sibling-comparative study was designed in the Indian Migration Study (IMS) to examine the impact of migration by using a counter-factual approach of comparing the risk factors of urban migrant with their non-migrant rural siblings (86). This design was primarily to "control" for the genetic predisposition of the CVDs and possibly the environmental influences within the family and the surrounding environment, as it was assumed that the lifestyles prior to migration might be similar between the two siblings but would divert once one sibling migrated to urban area and the other remained residing in origin rural area.

The Peru migrant study was initially designed as a cross-sectional study to assess the magnitude of differences in CVD risk factors among three independent groups: rural residents, rural-to-urban migrants and urban residents (87). However, an opportunity of extended funding converted this design to a cohort study: participants in the cross sectional study were re-contacted after five years and a follow-up study was conducted for one time to determine the effect of rural-to-urban migration on the incidence of CVD risk factors (88-90). Among the cross-sectional studies there was one study that was conducted in six middle income countries: China, Ghana, India, Mexico, Russia and South Africa to compare the NCD risk-factors in urban, rural and rural-urban migrant groups using nationally representative, cross-national data (81).

Although behavioural risk factors are important determinants of CVD, together nine out of 26 rural-to-urban migrant studies examined the effect of migration on diet and physical activity (Annexure 1.2) (78, 79, 81, 83, 84, 86, 87, 91, 92). These studies indicate that migration from a rural to an urban area has an impact on diet and physical activity of migrants, however the pattern was not consistent. The only longitudinal study with pre-migration data (conducted in Tanzania) showed that consumption of saturated fat intake, red meat and soft drink intake increased significantly over 12 months following migration (83). The same pattern was observed in the sibling-pair comparative migrant study of India where vegetable, as well as sugar, and meat consumption was higher in the migrant than rural group (93). In contrast, the multi-country study reported fruit and vegetable consumption, defined as over five portions per day, was lower in migrants than the rural group. Likewise, physical activity was decreased markedly following migration in the Tanzania study (83) and sedentary behaviour was found higher among migrant compared to rural dwellers (83, 91, 94).

Measurement of nutrient intake and physical activity at the population level is problematic due to reliance on self-report questionnaires which are prone to large measurement error, especially for such complex behaviours. Hence any self-report questionnaire needs validation before being introduced as an assessment tool. Among these studies, only two studies (84, 86) used the validated food frequency questionnaire (FFQ) as a tool to assess the usual diet. Other studies in Papua New Guinea (92) and India (91) used weighed method and 24-hour recall method, respectively, while only fruit and vegetable consumption was reported in the multi-country study (81). Looking at physical activity, the IMS and Peru migrant study reported to use a validated tool, being the Physical Activity Questionnaire (IMS-PAQ) (95) and International Physical Activity Questionnaire (IPAQ) respectively, whereas other studies did not mention any validated tool. Details of the tools are described in Annexure 1.2.

1.1.5 Migration, acculturation and changes of lifestyle

Acculturation is considered as one of the important areas in migrant health research as it has direct impacts on health and health behaviours among immigrant populations (96, 97). It is the process by which migrants adopt the values, norms, practices, customs, and attitudes of a host population and it takes place over time (98-100). Although migrants experience various disadvantageous circumstances in a new place (e.g., socioeconomic difficulties, establishing social network, language barriers or maintaining general health), they are reported to have better health than the origin and host populations, known as a 'healthy migrant effect' (64, 101-103). This selective migration process happens due to positive selection bias, as healthier people at the origin are physically and economically more able to migrate, or due to pre-migration health screening which means only healthy migrants are selected to work in new destinations (65, 97, 101). However, the health benefit diminishes in the course of acculturation into native society (102).

This acculturation process could be unidirectional (i.e., immigrants gradually adopt the culture of host society) or bidirectional (i.e., maintain most or some extent of the original culture and adopt certain aspects of host culture) (96, 100, 104-106). One influential bidirectional model is Berry's acculturation model which includes four acculturation strategies: (i) assimilation, also known as 'cultural shift', represents migrants who show negative attitudes to home culture and entirely adopt the new culture; (ii) integration, also known as bi-cultural orientation, which occurs when migrants maintain their culture of origin as well as adopting the new culture; (iii) separation, which happens when people reject the new culture and retain their original culture; and (iv) marginalisation which characterises individuals who show negative attitude towards both cultures (96, 104, 107-109). Another model of acculturation which is relatively new is the multidimensional model. This model is not about the general levels of overall acculturation, rather it focuses on the acculturation process that closely relates to individual cultural traits (110). Moreover, the migrants' choice of selecting acculturation strategies is neither entirely independent nor consistent across areas of daily life; they are not mutually exclusive in order to achieve targeted outcomes. For example, one could use the assimilation strategy at work while using the separation strategy to choose friends or food. So, unlike the bi-directional model, this model can explain selective and stepwise acculturation (65, 110-112).

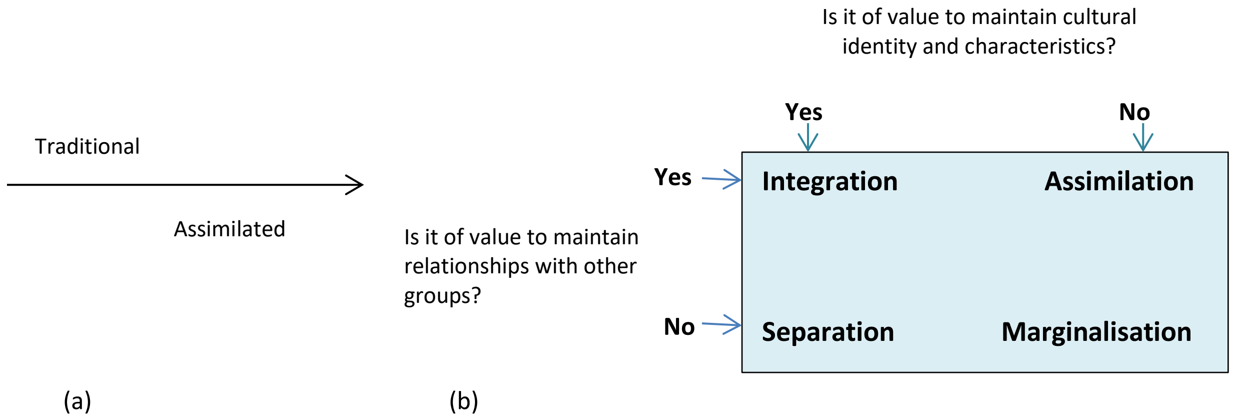

Figure 1. 2: (a) Simple model of uni-directional model of acculturation[5] (b) Berry's bi-directional acculturation strategy [6]

Each of these strategies has an impact on the physical and mental health of migrants (113). Acculturated migrants have more risk factors for CVD, such as hypertension and obesity due to adverse changes in lifestyle, diet and physical activity (114). A systematic review conducted on migrants from LMICs to high income countries indicated an overall positive correlation between acculturation and overweight/obesity. This review showed that the BMI increases with a higher degree of acculturation (97).

Lifestyle of migrants may change according to their receiving land, but it may perhaps differ with their own culture and family tradition. It is thought that those who possess old traditions and customs take time to absorb new cultures and inputting new things. Social and cultural qualities and attitudes act as resistant to change and are usually last to adjust during acculturation (115). For instance, Indian Americans who immigrated

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[5] 104. Flannery WP, Reise SP, Yu J. An empirical comparison of acculturation models. Personality and Social Psychology Bulletin. 2001;27(8):1035-45.

[6] 107. Berry JW. Immigration, acculturation, and adaptation. Applied psychology. 1997;46(1):5-34.

to the U.S. from India desire that their children reproduce their parents' cultural beliefs and values (116). Study showed that Japanese individuals migrating to the U.S maintain a Japanese lifestyle and their migration experience has been more gradual. Despite this lack of apparent acculturation, the risk of diabetes amongst Japanese people living in urban areas of the U.S. is 2-3 times higher than in Japanese people living in Japan (117). The slow process of acculturation may protect immigrants from adopting behaviours that compromise their health despite these behaviours being prevalent in the hosting land. On the other hand, this result is in contrast to another study which was conducted on Arab-American individuals, which showed that less acculturated Arab-Americans are generally at greater risk of diabetes than those with greater acculturation (118). So, the relation between acculturation and health status is complex and varies from population to population.

Acculturation takes place not only after crossing international boundaries but also moving from rural to urban areas (109). In the systematic review (74) of rural to urban migration and in the updated literature, eight studies examined some of the known markers of acculturation (i.e., length of urban stay). The recent prospective Peru migrant study, where length of urban stay was used as a surrogate measure of acculturation, reported that rural-to-urban migrant and urban groups had an 8-to-9.5 times higher risk of developing obesity than rural group (119). Another cross-sectional migrant study on CVD risk factors and duration of urban dwelling, which was conducted in India, showed that adiposity increased rapidly within one decade after moving to the urban areas whereas other CVD risk factors such as BP and diabetes developed progressively up to the fourth decade (120). However, the degree and pace of acculturation varied across population.

1.1.6 Rural-to-urban migration and CVD risk in Bangladesh

1.1.6.1 Bangladesh- a brief country profile

Bangladesh, officially known as The People's Republic of Bangladesh, is a fertile and densely populated delta country in south Asia bordered by the Bay of Bengal, India and Myanmar. It's Padma, Meghna and Jamuna rivers create vast riverine networks and enhance the fertility of the soil enormously. On the southwestern part, the Sundarbans, an enormous mangrove forest belt shared with Eastern India, is home to the world famous Royal Bengal tiger. Nepal, Bhutan and China are located near Bangladesh but these countries do not share a border with Bangladesh (121). The country's total land area is 143,998 sq. km with a population of approximately 149.8 million which makes Bangladesh the 7th highest densely populated country (976 Population/Km^2) in the world (122).

Dhaka is the capital and the largest city of the country, followed by Chittagong, which has the country's largest port and is the second largest city. Cox's Bazar, the longest natural sea beach in the world with an unbroken length of 120 km, is situated in the south eastern part of Bangladesh. Administratively the country is divided into eight Divisions, 64 Districts, 545 Thanas and 4543 Unions (122). By religion about 90.4% people are Muslim, with the remaining percentage a mixture of Christian, Buddhist and Hindu (122). The average literacy rate is 47.68% (122) . Life expectancy has increased from 64 years to 73.4 years within the last 20 years and currently 7% of the total population is over 60 years (122). Population growth rate is 1.04% and the urban rural population ratio is 35.8:64.2 (2017) (122). The climate of Bangladesh is predominantly tropical in nature. Very high humidity, high temperature and heavy rainfall are characteristic features of this region (121). These features and unique geographic location make it prone to devastating cyclones, floods and natural calamities.

Figure 1. 3: Map of Bangladesh

Bangladesh was born from the War of Independence in 1971 as the world's second poorest nation. Since then the country has surprisingly improved in all aspects. Based on the international poverty line of $1.90/person/day, it reduced poverty from 44.2% in 1991 to 13.8% in 2016/17 (123). The GDP growth was 6% over the decade, reaching to 7.3% in 2016/2017 (123). This improvement enabled Bangladesh to reach lower middle-income country status in 2015. In 2018, Bangladesh fulfilled all three eligibility criteria for graduation from the UN's Least Developed Countries (LDC) list for the first time and is well on track for graduation in 2024 (123).

1.1.6.2 Internal migration in Bangladesh

Bangladesh has been experiencing rapid urbanisation for the past several decades. The urban population is growing so fast that it will rise from its current level of 53 million people to 79.5 million in 2028 (124). While the annual population growth rate is 1.2% at national level, the percentage of urban growth is more than double at about 3.3% (125). Bangladesh will be an urban country in 2039 when the majority of people will live in urban areas. Most of this growth is driven by migration from rural areas (124). According to the Bangladesh Population and Housing Census 2011, the rural to urban migration rate was 4.29/1000 population for the whole country and 29.5/1000 population for Dhaka, the capital city (126).

There are various reasons why people migrate internally in Bangladesh. Every year, thousands of destitute victims of natural disasters such as river erosion, landslide, soil erosion, salinity, flood and drought come into the cities from rural areas. Others come in the hope of better life. Even today, both poor and better off people pursue migration as a livelihood strategy in Bangladesh (127). Now people are far less dependent on agriculture and related work. They increasingly depend on off-farm livelihoods, which often involve some form of migration (128). It was found that approximately two-fifth of rural households in Bangladesh sent adult members to seek work in an urban area (129). Most economic migrants to urban areas are young males, but this has changed significantly with the recent increase in demand for female labour in the ready-made garment factories of Dhaka and other metropolitan areas (128). Other reasons for internal migration in Bangladesh include education, political turmoil, low living standards, demand for specific skills set and knowledge and marriage (61).

The Dhaka, Khulna, Rajshahi and Chittagong divisions have higher migration rates than the other divisions. Dhaka division, being the capital city, is the most favourite migration destination in the country. For example, 34.13% people of the Rangpur and 26.71% of the Chittagong divisions migrated to Dhaka, followed by Khulna (23.87%), Rajshahi (22.78%) and Barisal (21.20%). Among rural migrants, 41% lived in the Dhaka division in 2011 (61). However, the higher rate of migration to the Dhaka division is not surprising as all industrial, economic, political and administrative institutions are concentrated in Dhaka.

The effect of internal migration cannot be avoided from the socio-economic development, poverty alleviation and re-distributional viewpoint of a country. For the last decade, rural-urban migration has been increasing quite rapidly because of growing population, the unemployment rate in rural areas and creation of new jobs in urban areas. As a result, the urban population is growing more rapidly than the total population. This migration has a profound effect on the health sector. Thus, the government, as well as the health decision-makers, have to research more in this area for the balanced and sustainable development of the country.

1.1.6.3 CVD and risk factor burden in Bangladesh

CVD has also been emerging as an important public health problem in Bangladesh. In the GBD Study 2016 on mortality, stroke and ischemic heart disease (IHD) were the top two causes of Years of Life Lost (YLL) in Bangladesh (130). The WHO Non-communicable Diseases (NCDs) Country Profiles 2011 report illustrated that about 27% of deaths from all causes occurred in Bangladesh due to CVDs (26). Due to the lack of a good surveillance system, there is little population-based data on CVD. However, according to the preliminary report of the Bangladesh Household Income and Expenditure Survey (HIES) 2010, around 7.3% of the population had chronic heart disease (7.2% in rural & 7.7% in urban) and the average duration of ailment due to chronic heart disease was 75.4 months (131). Now this country is facing a dual burden of existing infectious diseases and escalating rise of NCDs.

Although Bangladesh most likely has the highest rates of CVD among all South Asian countries, this area is the least studied (132). Only a few small-scale studies are available. The first prevalence study of heart disease may have been that conducted in 1976 amongst 7062 people of different age groups in Dhaka City and in a village, with reported prevalence of 0.33%. A recent systematic review of studies on Bangladesh indicates that the rate could vary from 0.33% to 19.6% (133). Even though there are marked differences in prevalence values, there appears to be a rising prevalence of CVD in Bangladesh. A study conducted in a rural area reported that the age standardised CVD mortality rates increased by 30-fold (from 16 deaths/100,000 to 483 deaths/100,000) in males and 47-fold (from 7 deaths/100,000 to 330 deaths/100,000) in females over the period 1986 to 2006 (134).

The increasing trend of CVD is linked to a few common risk factors which are unhealthy diet, physical inactivity, tobacco, harmful use of alcohol, obesity, raised blood pressure, and raised blood cholesterol and glucose (135). In the GBD 2010 study, three CVD risk factors i.e, smoking, unhealthy diet and hypertension ranked as the 1st, 3rd and 5th leading risk factors in Bangladesh, respectively (136). The INTERHEART Study reported that the mean age of MI among the Bangladeshis was 6 years lower than the non-South Asians due to high levels of risk factors such as diabetes and high cholesterol, and low levels of protective factors (physical activity and dietary habits) (12, 137, 138) .

The three nationwide periodical surveys of NCD risk factors in Bangladesh, following the WHO STEPS strategy (2006, 2010 and 2013), reported clearly that not only behavioural risk factors e.g., low intake of fruit/vegetables, physical inactivity but also metabolic risk factors e.g., overweight, hypertension and documented diabetes have been increasing (135, 139, 140). The age adjusted prevalence of risk factors in the 2013 NCD survey was: low intake of fruit/vegetables (93.3%), low physical activity (38.6%), any form of tobacco (45%), overweight (20.3%), obesity (5.1%), hypertension (23.1%) and documented diabetes (5%) (139). A recent meta-analysis of population-based CVDs risk factor studies in Bangladesh, synthesising data up to 2014, reported pooled prevalence of 14% of hypertension, 24% of obesity, 6% of diabetes, 18% of dyslipidemia and 40% of smoking (141). Although few studies reported prevalence of metabolic risk factors of CVD in Bangladesh (1, 132, 133, 139, 141), there is a paucity of dietary pattern and physical activity data, or these two risk factors were not properly measured.

Two demographic features might explain the increasing trend of CVD and its risk factors in Bangladesh. Firstly, the ageing population; currently the proportion of the population aged 60 years or more is 7% and this is projected to increase hugely, such that the elderly will make up 18.8 percent of the total population by the mid-21st century, potentially increasing the CVD burden greatly (142). Around 68% of deaths in Bangladesh are due to NCDs and other chronic health conditions including old age complications (143). Secondly, the rapid urbanisation of Bangladesh is likely to have profound implications for its population health profile. It has been long observed that the processes of urbanisation associated with migration leads to dietary changes, physical inactivity, and high tobacco intake, which ultimately lead to metabolic changes (7, 57, 144). This, coupled with the possibility of unmet demands by health care providers, may escalate the CVD burden unless a primary prevention effort takes place.

1.1.6.4 Rationale of the present study

A recent consensus statement (2007) highlighted the need for data on the impact of urbanisation on NCDs (145). The urbanisation process in developing countries occurs due to growth of existing urban populations, expansion of urban boundaries, and rural-to-urban migration (146). As urban areas of developing countries are growing much faster than rural areas, partly through migration from rural to urban areas, it is vital to more fully understand the impact of urban migration on health. Various studies on the health effects of migration have largely focused on movement between countries (147). These studies may not be a good analogue as Odone et al (66) argue that domestic or international migration can contribute differentially to CVD risks.

The literature review on the effect of rural-to-urban migration on CVD risk factors in developing countries showed that CVD risk factors were not uniform across countries. This discrepancy can even be observed in a multi-country study by Oyebode et al., in the country specific analysis of CVD risk factors (81). The inconsistency of findings observed might be due to the cultural difference, level of urbanicity in each country and degree of acculturation to the urban life. Moreover, country-specific definition of urban and rural might be an important factor as urban living may develop in rural areas.

Thus, it is not conceivable to apply one country's data to another country and predict the effect of urbanisation on CVD risk factors. The country-specific evaluation of the effect of rural-to-urban migration on CVD risk factors is relevant owing to its huge public health consequences, as major risk factors of today will be the diseases of tomorrow. Hence, there is a reason to believe that the impact of unhealthy lifestyles in Bangladesh would vary according to social-economic factors, duration of residency in urban environment, acculturation, degree of exposure and genetic predisposition.

So far, the studies in Bangladesh are limited to descriptive epidemiology of CVD such as the high burden of CVD and its projection or the rural-urban distribution of CVD across the country. However, there is a limited analytical level of information available to shed light on causal determinants and high-risk groups, to allowing for target development and setting of priorities by policy makers. For example, the urban-rural comparison only suggests that urban population is at higher risk of CVDs, but does not give insights as to how these risks develop over time (148). Urban migration study offers good opportunity to understand the contribution of environmental exposure for progression of cardiometabolic risk over time. Furthermore, to what extent the difference arises between urban and rural population may depend on SES differences. It is possible that with economic growth those that can afford a "westernised lifestyle" are at high risk regardless of place of residence. Similarly, the change in CVD risk of rural-to-urban migrants after migration may also depend on SES. If a migrant is from a high SES area, limited impact on CVD risk might be visible after migration. But migrants from a low SES area would find themselves at greater CVD risk due to opportunity to mobilise on the SES ladder once moving to the city.

Moreover, movement to an urban area itself is not enough to change the risk profile, acculturation to the urban lifestyle plays a vital role here. It is expected that those who possess old traditions and customs will take time to absorb a new culture and new behaviours. Even though Bangladesh is a country with rich culture and with many customs, there is a need to explore what kind of and at which pace lifestyle changes, e.g., dietary habits, physical activity, tobacco consumption etc. are occurring among migrants as a consequence of urbanisation. The Bangladesh Urban Health Survey (UHS), which was held only in urban areas, collected data on migrants and some CVD risk factors. However, behavioural factors such as diet, physical inactivity and dyslipidemia were not measured in this survey and no analysis was done to find out the association between migration, CVD risk factors and the role of SES or acculturation despite data being collected (149). To the best of our knowledge there are no studies in Bangladesh to find out the effect of rural-to-urban migration on CVD risk factors.

As diet and physical activity are complex behaviours to measure, validated and precise instruments are needed to measure the habitual diet and activity levels of the population and the impact of any intervention. The nationwide periodical surveys of NCD risk factors in Bangladesh follow the WHO STEPS strategy, which used only fruit and vegetable intake, and the Global Physical Activity Questionnaire (GPAQ) for diet and physical activity, respectively. These tools either have limited validity (GPAQ) or missed to measure individual habitual dietary intake or habitual physical activity. Thus, validated diet and physical activity tools are needed in Bangladesh to measure these lifestyles for both urban and rural populations.

1.2 Study aims and Thesis structure

The overall aim of this thesis was to assess the differences in lifestyle risk factors (diet and physical inactivity) and their impact on metabolic risk factors of cardiovascular diseases among rural-to-urban migrants and rural non-migrants. To achieve this aim a series of studies were conducted and are reported in this thesis.

Following the introduction, **Chapter 2** reports epidemiological research using existing nationally representative Urban Health Survey data collected in Bangladesh. In this chapter we identified the effect of migration on CVD risk factors, and the role of SES and the impact of acculturation indicators on CVD risk. Further, we assessed whether CVD risk factors among migrants vary by place of residence, that is, in six divisions and three domains such as slum, non-slum and district municipalities.

Chapter 3 consists of a series of validation studies to be used in migrant and non-migrant sibling study as well as in future CVD risk factors surveillance in Bangladesh. There are three sub-chapters under this chapter, and all are written as a manuscript format:

The **sub-chapter 3a** aims to determine the criterion validity of the new version of the GPAQ (used in the WHO NCD risk factors surveillance in Bangladesh) in both rural and urban populations using accelerometer data as the criterion measure of physical activity.

Sub-chapter 3b describes the development and validation of a physical activity questionnaire for use in Bangladesh, termed as the Past Year Physical Activity Questionnaire (PYPAQ), to assess culturally relevant habitual moderate-to-vigorous physical activities (MVPA) in various domains over a year. Further, this sub-chapter also examined the seasonal variation in different physical activity domains as measured by the PYPAQ by area of residence.

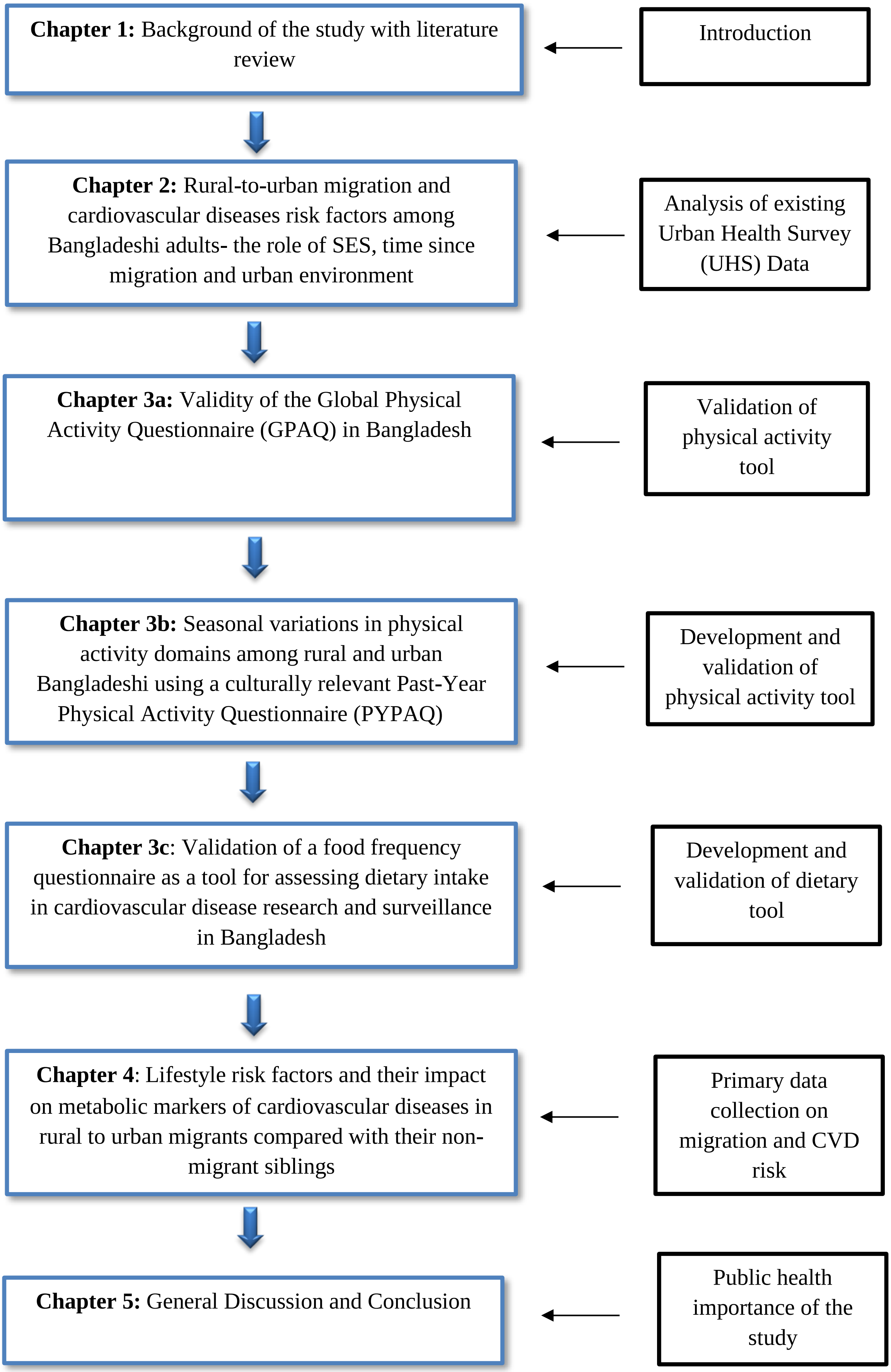
The third **sub-chapter 3c** describes the validation of the FFQ using the 24-hour recall methods and corresponding nutritional biological markers.

Chapter 4 describes findings of a sibling comparative study to compare CVD risk factors among migrants & their rural siblings and to examine whether the CVD risk factors vary with migration indicators.

Chapter 5 summarises the key findings from all the studies described in chapters 2-4 and provides a general discussion with strengths and limitations of the thesis. Furthermore, a brief discussion on policy implication of the thesis findings and future directions for research are provided. Finally, an overall conclusion of the thesis is presented.

All **appendices** are presented at the end of the fifth chapter. Appendices included data collection tools of empirical research, tables and graphs.

Figure 1. 4: Schematic overview of the structure of this thesis



Chapter 2

Rural-to-urban migration and cardiovascular diseases risk factors among Bangladeshi adults- the role of socioeconomic status, time since migration and urban environment

2. Urban Health Survey study

2.1 Introduction

The rise of cardiovascular diseases (CVDs) in developing countries has been linked to progressive urbanisation (24, 36, 57). Cross-sectional studies on comparisons of urban and rural areas have demonstrated higher rates of CVD risk factors for urban individuals (141, 150-152). However, this comparison only suggests that the urban population is at higher risk of CVD, but does not give insights as to how these risks develop over time (148). Urban migration studies offer good opportunities to understand the contribution of environmental exposure in the progression of cardiometabolic risk over time. Initially urban migrants are healthier than the urban host population however, with increasing length of residence, migrants are acculturated to the urban diet and other lifestyles (e.g., physical inactivity) which increase the risk of CVD (153-155). Some studies on rural-to-urban migration have also demonstrated that body fat increases rapidly just after migration, whereas other cardiometabolic risk factors evolve gradually (79, 120). However, this process differs from population to population, as the relationship between environment, acculturation and health status is complex (8, 117, 118, 156).

Urbanization is proceeding rapidly in Bangladesh. The percentage of urban growth has been estimated at about 3.5% per year (142) and according to the Bangladesh Population and Housing Census 2011, the rural to urban migration rate was 4.29 per 1000 persons per year for the whole country (126). As urbanisation in Bangladesh is happening so rapidly, partly through migration from rural to urban areas, an improved understanding of its impact on cardiovascular risks after migration is paramount.

Role of socioeconomic status

According to Steptoe & Marmot, socioeconomic status (SES) plays an important role in determining health (157). Research has shown that most of the migration held due to economic reasons, therefore it is generally expected that a socioeconomic gradient in health will eventually emerge in migrant group (158, 159), including in CVD risk. The theory of cardiovascular epidemiologic transition posits that initially risk factors and disease burden remain higher in the affluent group, as they are the first who can afford products that are associated with unhealthy behaviours (e.g., cars, TV, eating out), which increase their CVD risk (160). However, these unhealthy behaviours are eventually transferred to the lower social class, while the early adopters then reduce their risk in response to new knowledge and new technologies (36, 160). In the Indian Migration Study (IMS), evidence of effect modification by SES was found for the test of linear association between urban life years and percentage of body fat and the change in adiposity appeared in migrant from low socioeconomic position (120). A systematic review of acculturation and obesity showed that when people migrated from low-to-middle income countries to high income countries, risk of overweight/obesity increased (97). The 'healthy migrant effect' resolved over time through acculturation to the host culture and adaptation of unhealthy behaviours (97). However, the relation between acculturation and health status is not uniform across populations. The Peru Migrant Study, for instance, examined whether SES and acculturation (defined as language use and proficiency; ethnic-social relations and media use) could predict the risk of overweight/obesity. They found that only high SES, but not acculturation, was directly associated with overweight/obesity in that population (161).

Role of environment

Environmental mega influences such as transport infrastructure, urban design and globalization of food were identified as major contributors to the rise of CVD risk in the process of urbanisation in developing countries (24). Likewise in Bangladesh, the rate of urbanisation varied substantially between a mega city, like Dhaka, to a City Corporation, like Chittagong, or other urban area (district municipality/large town), like Thakurgaon (126). Consequently, patterns of risk factors of CVD cannot be the same in these urban areas due to the differences in the man-made and natural environments, such as availability of fast food, transport or opportunity for physical activity. For example, in Dhaka cheap fast food shops or street cafés and vendors are more frequent than in District Municipalities like Thakurgaon. The food sold by these shops are often prepared in an unhealthy way i.e. fried, using palm oil rich in saturated or trans-fat, and heavily salted. Moreover, cities are also divided into slums and non-slum areas, and rural poor migrants generally settle in slum and squatter settlements in the city (128), exposing themselves to the cheap street fast food. Cities are characterized by large inequalities in health-related conditions in slum and non-slum areas and the pattern of CVD risk may be different accordingly. For example, in Indian studies, urban slum dwellers reported lower intake of fruits and vegetables and higher consumption of tobacco than non-slum dwellers. On the other hand, urban non-slum residents were more physically inactive and their saturated fat intake was also higher than urban slum residents (162, 163). Thus, a risk based stratification of urban areas is required to allow for valid comparison.

Acculturation

Apart from the diverse physical environment that migrants are exposed to, there are also differences in their social reality and degree of acculturation. The most prevailing explanation for the better health of migrants at arrival is the 'healthy migrant hypothesis'. This hypothesis predicts that migrants are a selectively healthier group compared to the average health status of the origin and host population (101, 102). This selective migration process happens due to positive selection bias, i.e. that healthier people at the origin are physically and economically more able to migrate (97, 101). However, the health benefit deteriorates during the course of acculturation into native society (102). Acculturation is considered one of the important areas in immigrant health research as it has a direct impact on health and health behaviour among immigrants (96, 97). It is the process by which migrants adopt the values, norms, practices, customs, and attitudes of a host population over time (98-100). However, this process could be unidirectional (i.e., immigrants gradually adopt the culture of host society) or bidirectional (i.e., maintain most or some extent of the original culture and adopt certain aspects of the host culture) (96, 100, 104-106). One influential bidirectional model is Berry's acculturation model, which includes four acculturation strategies: assimilation, integration, separation and marginalisation (107). Assimilation occurs when migrants show negative attitudes to home culture and entirely adopt the new culture. In contrast, integration occurs when migrants maintain their culture of origin as well as adopting the new culture. Separation happens when migrants reject the new culture and retain their original culture. Marginalisation occurs when individuals show a negative attitude towards both cultures (96, 104, 107-109).

Acculturation takes place not only after crossing international boundaries but also moving from rural to urban areas (109). However, studies on acculturation and migrant health have largely focused on movement between countries (96, 97, 105, 108), whereas very few have focused on rural-to-urban migration (120, 161). A variety of proxy measures are used as indicators of acculturation in population studies such as length of residency, place of birth, age at migration or language use by migrants (96, 97, 108). Proxy measures are quick and easy to quantify by population surveys nevertheless, it is difficult to quantify complex and multidirectional acculturation with simple static indicators (96, 97, 108).

Despite the large and fast movement of rural residents toward urban areas in Bangladesh, to the best of our knowledge, no study has been conducted to date on rural-to-urban migrants' health status. This study therefore aimed to examine the association between CVD risk factors and duration of urban life after migration, taking into account SES and exposure to different urban areas of residency. In doing so, this study may help to improve knowledge of transitions of chronic disease, identify high risk populations in Bangladesh as well as provide a set of suggestions for non-communicable disease control.

2.2 Objectives

1. To examine whether the prevalence of CVD risk factors differ between rural-to-urban migrants and urban residents, and the role of SES in explaining these differences
2. To determine the association between CVD risk factors and ‘exposure to urban years’ of rural-to-urban migrants as a potential acculturation marker, after accounting for demographic and socioeconomic status
3. To examine the distribution of CVD risk factors among rural-to-urban migrants according to the environment they settled in i.e. urban areas (division and slum/non-slum)

2.3 Methods

2.3.1 Ethics approval

This study was approved by the Western Sydney University Human Research Ethics Committee (HREC # H11056). We obtained data following approval from the University of North Carolina at Chapel Hill (UNC). Informed consent was obtained from all subjects.

2.3.2 Data source

A representative set of cross-sectional data collected via the 2006 Bangladesh Urban Health Survey was used for this study. The 2006 Urban Health Survey (UHS) is a nationally representative sample survey of the urban population. It was implemented through a collaborative effort of the National Institute of Population Research and

Training (NIPORT) and Measure Evaluation, UNC, USA, Associates for Community and Population Research and funded by the United States Agency for International Development (USAID)/Bangladesh (164). Fieldwork for the main survey was conducted between March and July 2006. The data of the UHS was made publicly available on June 24, 2013. The survey data was downloaded from the Odum Institute Dataverse Network, a data archive maintained by UNC's Howard W. Odum Institute for Social Science (165).

The survey collected information from urban populations of the six City Corporations[7] and overall District Municipality[8] populations using a multi-stage cluster based approach. In addition, data were collected from three overall domains; slum neighbourhoods in City Corporations, non-slum neighbourhoods in the same City Corporation and District Municipalities. These three 'overall' domains were again divided into eight more statistical domains [9] for sampling purposes.

In the beginning, sample frames of slum and non-slum areas of six City Corporations were built using information from the 2005 Census and Mapping of Slums (CMS) (166) and the mahalla[10] mapping. The primary sampling units (PSUs) for slum areas were generated from slum communities, and non-slum PSUs consisted of the non-slum areas of each mahalla. District Municipalities were included as domains, and sample frames of the 2004 Bangladesh Demographic and Health Survey (2004 BDHS) were updated and used.

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[7] In 2006, there were only 6 City Corporation- Dhaka, Chittagong, Khulna, Rajshahi, Barisal, and Sylhet; there was no Dhaka North, Dhaka South, Rangpur, Comilla, Narayanganj or Gazipur City Corporation

[8] Urban administrative areas that are a tier below the City Corporations

[9] The 8 statistical domains- Dhaka Metro Area large slum areas; Dhaka Metro Area medium and small slum areas; Dhaka Metro Area non-slum areas; Chittagong City Corporation slum areas; Chittagong City Corporation non-slum areas; Khulna, Rajshahi, Barisal and Sylhet City Corporation slum area; Khulna, Rajshahi, Barisal and Sylhet City Corporation non-slum area and District Municipalities

[10] Mahallas are the smallest administrative division of City Corporations

Finally, 64 PSUs were selected randomly with probability proportionate to size (Table 3.1) from each of the eight statistical domains. Further, 25 households (secondary sampling unit or SSU) were selected randomly from each PSU. Within each household, all ever-married men and women aged 10-59 years[11], and all other men and women aged 18-59 years were targeted for interview. Thus, the overall targeted sample was 64,000 individuals (8 domains X 64 PSUs X 25 HH X approx. 5 individuals/HH).

At the community level, 510 out of 512 selected PSUs could incorporate for fieldwork. The HH response rates were quite high for slum (94.8%), non-slum (94.2%) and District Municipalities (95.3%). Eligible men and women response rates in the various domains ranged from 82%-89% and 90%-95%, respectively.

Figure 2.1 outlines the administrative geography of Bangladesh (167) and Table 2.1 shows the data on the population sizes of the six divisions[12] and City Corporations, from Bangladesh Bureau of Statistics (122, 168).

[11] In Bangladesh child marriage is still exists, though it is not legal

[6] In 2006 the administration of Bangladesh was divided into 6 regions called Divisions. Each division is usually named after the major city and it is also served as the administrative headquarter of that Division.

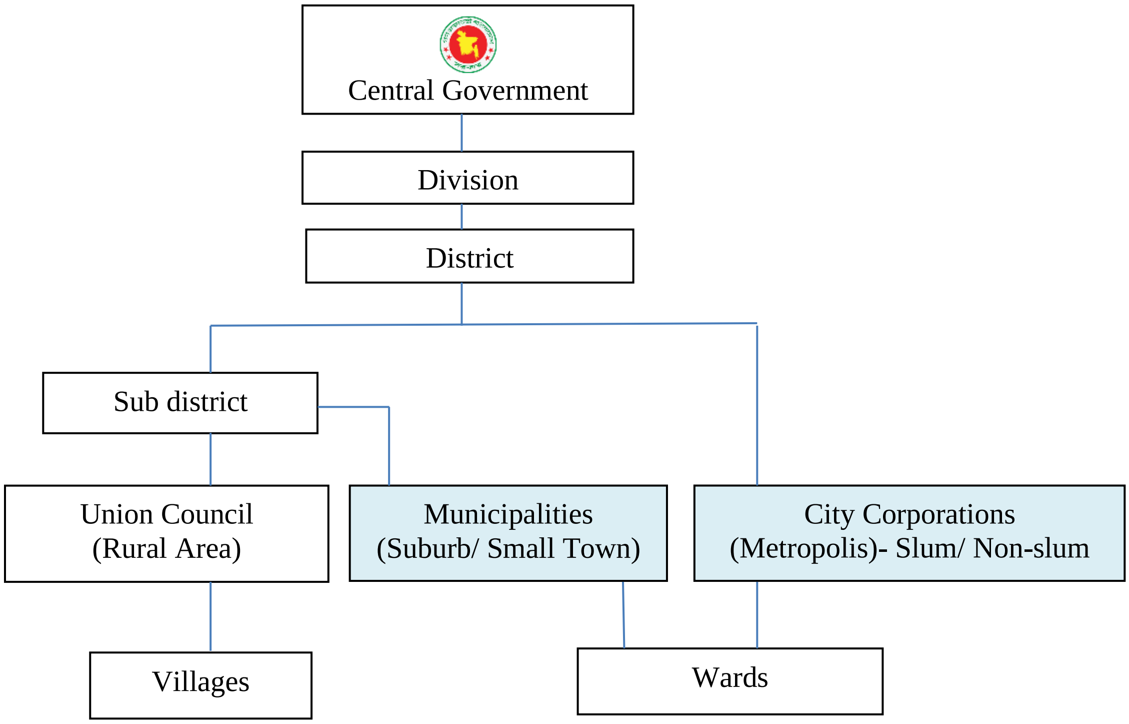


Figure 2. 1: Administrative geography of Bangladesh

Table 2. 1: Population of 6 Division and City Corporations

Name	Division		City Corporation	
	2001	2011	2001	2011
Barisal	8549026	8652371	193,000	328,278
Chittagong	25505197	29558357	2023,000	2581,643
Dhaka	41127949	49321690	5327,000	6970,105
Khulna	15418650	16309403	770,000	663,342
Rajshahi	17129332	19225905	389,000	448,087
Sylhet	8307941	10296995	263,000	479,837

2.3.3 The analytical sample

In the UHS a total of 28,010 participants were interviewed. The sample for this report comprises 27,792 participants of both genders (M: 13,691; F: 14,101) selected from all ever-married people aged 10-59 years and all other adults aged 18-59 years within each 2006 UHS household (Figure 1). We have excluded 218 individuals as their previous place of residence was abroad.

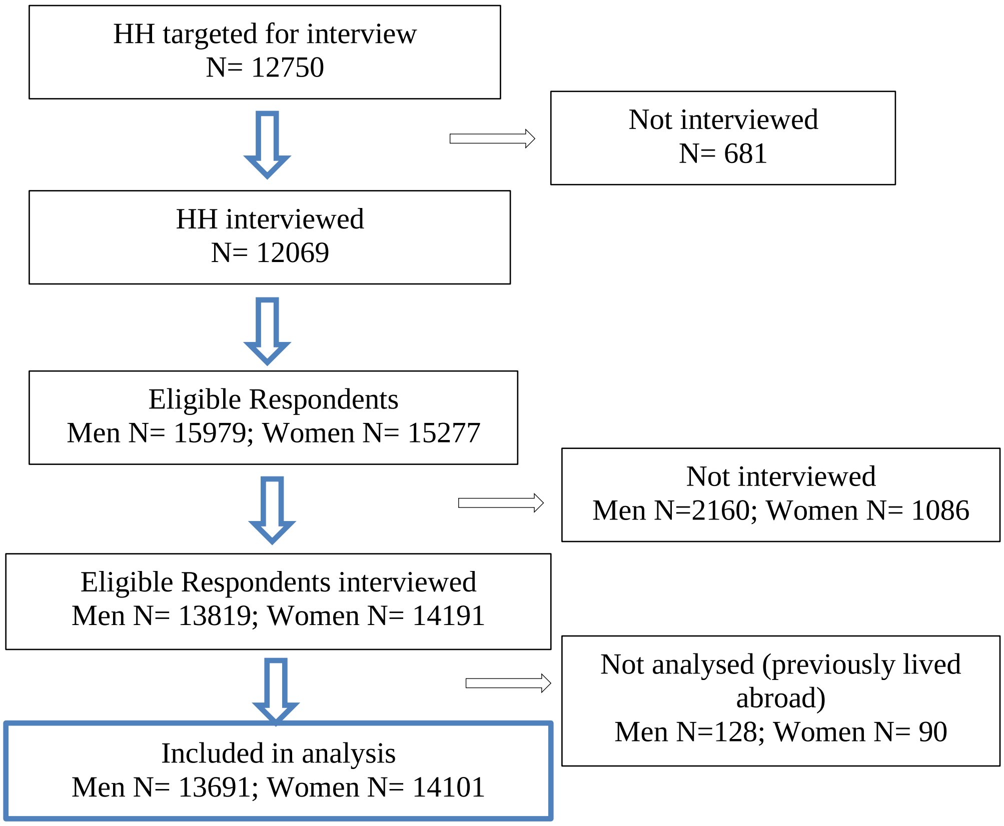


Figure 2. 2: Flow chart of sample taken from UHS 2006

2.3.4 Data collection method

In 2006 UHS data were collected at community, household and individual level by interviewer administered questionnaire. The community questionnaire was administered to community leaders. A basic household-level questionnaire usually administered to the female head which included a full roster of household members. Within each household, eligible individuals who were married and aged 10-59 years and all other adults aged 18-59 years were interviewed face-to-face for detailed information. The adult questionnaire (Annexure 2.1) included:

- Basic individual characteristics
- Birth history (women only)
- Antenatal and postnatal care, and breastfeeding history (women only)
- Health including general health, activities of daily living and recent serious illness and injuries
- History of sexually transmitted disease
- Mental health
- Violence
- Smoking, alcohol and drug use and criminal victimisation
- Physical measurements including height, weight, blood pressure and blood glucose.

Before going to the final data collection, a pre-test was conducted for women's questionnaire, men's questionnaire and household questionnaire. Fieldwork was carried out by 17 trained interviewing teams with each team consisting of seven members; one male supervisor, one female supervisor, two male interviewers, two female interviewers, and one field assistant. For blood pressure and blood glucose measurements, one paramedic was included in five teams.

The height and weight of the study participants were measured following a standard method for all women and men aged 18-59 years and of ever married women and men aged 10-59 years in selected households. Blood pressure (BP) and fasting blood glucose (FBG) were measured in randomly selected subsamples of adults over age 35. District Municipalities were not included for anthropometry, BP and FBG measurement. A mercury blood pressure machine was used for BP measurement and the measurement was taken in a seated position. Blood glucose was measured using the HemoCue Glucose 201+ in whole blood obtained by finger prick from capillaries in the middle or ring finger of the left arm after an overnight fast.

2.3.5 Study variables

Exposure variables

The primary exposure of this study was rural-to-urban migration. Current place of residence of all respondents in 2006 UHS was urban, either in a city or town. We defined a rural-to-urban migrant based on the question ‘place of prior residence’[13] as those who lived in a rural area prior to living in an urban place. Non-migrant urban respondents were defined as those who always lived in an urban environment based on two questions; either they ‘always lived’[14] in their current place of residence or if their ‘prior place of residence’[6] was also an urban area (excluded those who had lived abroad).

[13] Annexure 2.1: 2006 UHS Men and women questionnaire- question no. 128
[14] Annexure 2.1: 2006 UHS Men and women questionnaire- question no. 127

The second exposure variable of migration indicators was length of years the migrant had lived in an urban area as an indicator for potential “acculturation”. The variable ‘length of years lived’ derived from the question ‘how long have you been living continuously in current place of residence’[7]. The number of years lived in an urban place was categorised by quartile (Q1, Q2, Q3 & Q4). Another migration indicator was reason/s for migration. Respondents were asked their main reasons for moving to the current place[15] and we categorised into two broad categories which were; work or education and familial reasons.

The third exposure variable was the urban environment migrated to; six divisions and three domains which were slum, non-slum and district municipalities.

Outcome variables

The main outcome variable of this report was CVD risk factors. The CVD risk factors available in the UHS were cigarette and bidi[16] smoking, alcohol intake, overweight & obesity, hypertension, diabetes and mental health disorders.

A current smoker was defined as having smoked either cigarettes or bidi within the last one month. Alcohol intake was reported as participants who had ever used alcohol. UHS respondents were asked if they had ever used alcohol or illicit drugs in one question, which was a double-barrelled question. However, we use the term ‘alcohol intake’ instead of ‘alcohol/drug use’ throughout the chapter.

In this study, overweight and obesity were categorised using Asian cut-off values (169) which were underweight (< 18·5 kg/m^2), normal (18.5-23.0 kg/m^2), overweight (23-

[15] Annexure 2.1: 2006 UHS Men and women questionnaire- question no. 129
[16] Bidi is a small hand-rolled cigarette made of low grade unrefined tobacco flakes that have been dried, crushed, and rolled into a Tendu leaf.

27.5kg/m^2), and obesity (> 27.5 kg/m^2). Hypertension was defined as a systolic blood pressure ≥ 140 mmHg or a diastolic blood pressure ≥ 90 mmHg, or current treatment with an antihypertensive medication (164). Based on World Health Organization (WHO) guidelines, Impaired Fasting Glucose (IFG) was defined as a fasting blood glucose level of 6.1 mmol/L to 6.9 mmol/L and diabetes was defined as a level ≥7.0 mmol/L or self-reported diabetes medication use (170).

Mental health disorders were measured by a 20 item Self-Reporting Questionnaire (SRQ20) developed by WHO particularly for developing countries (171). SRQ20 is not a clinical diagnostic tool but it can screen for probable mental health disorders such as; depression, anxiety disorders and somatoform disorders among individuals (172). We used the cut-off value of ≥8 for 'probable case (173).

Comorbidity factors

We also reported self-reported health outcomes (SRH) commonly assessed included activities of daily living, personal perceived health status, recent experience of serious illness and recent injuries. The perceived health status of respondents was assessed by asking about their current health status in general[17].

Health related functional difficulties in past four weeks were assessed by asking "During the last four weeks, were you unable to do your normal work or regular activities due to any health problem?". Activities of daily living (ADL) were assessed by seven questions[18] which have been grouped into the clusters- personal care ADLs (dress, use toilet, and stand up from seated position in a chair); motion ADLs (stand up from seated position on floor, squat/stoop/kneel) and strength/mobility ADLs (carry

[17] Annexure 2.1: 2006 UHS Men and women questionnaire- question no. 401

[18] Annexure 2.1: 2006 UHS Men and women questionnaire- question no. 402b

a 10 kg load, walk one kilometre). In response respondents were asked to choose one of the three responses: "can do easily=1", "can do with difficulty=2" or "cannot do at all=3", which were further classified as "no limitation (1)" and "limitation (2 & 3)". Respondents were also asked whether they had experienced any serious illness or injury in the last year[19].

Covariates

In this study following covariates were used:

- Age – for this report we used participant's age as a categorical (≤20, 21-30, 31-40 and >40 years) and continuous variable;
- Gender - male, female;
- Educational status - illiterate, literate;
- Highest grade of education - primary, high school and university level;
- Current working status - yes, no;
- Religion - Islam, others;
- Marital status - currently married, never married and others;
- Monthly income - quartile (Q1, Q2, Q3, Q4) and continuous;
- HH wealth quintile - Q1, Q2, Q3, Q4 & Q5;
- Divisions - Barisal, Chittagong, Dhaka, Khulna, Rajshahi and Sylhet; and
- Overall domain - slum, non-slum and District Municipalities.

[19] Annexure 2.1: 2006 UHS Men and women questionnaire- question no. 403 & 404

2.3.6 Statistical analysis

The analyses include descriptive statistics of the selected variables. The gender-specific prevalence of CVD risk factors was estimated for the rural-to-urban migrant and urban groups. The stratification by gender was guided by the gender differences in lifestyles and by CVD risk. The $\chi 2$ test was used to establish statistically significant differences between proportions and a p value <0.05 was considered as the minimum level of significance. Multivariate logistic regression analysis was performed to investigate the relationship between each CVD risk factor (as dependent variable) and migration status (migrant/urban) (as predictor). A sub-analysis on rural-to-urban migrants only was conducted to examine the association between each CVD risk factor and migration indicators (length of urban stay & reasons for migration). The role of SES in explaining the association between migration status and the CVD risk was further tested by crude, stratum-specific and Mantel-Haenszel adjusted OR. Test for trend was determined by the significance of the continuous duration variable in the logistic regression model. Smoking and alcohol intake was not included in regression analysis for women because only eight and five women reported smoking and alcohol consumption, respectively. All analyses were carried out for each gender separately. The data entry and analysis were performed using SPSS version 23.0 (SPSS Inc, Chicago, IL).

2.4 Results

2.4.1 Study population characteristics and migration status

Table 2.2 shows the socio-demographic characteristics of all respondents by migration status. A total of 27,792 participants were included in the analyses, of which 14101 (51%) were women. Overall 14,167 (M: 7278; W: 6889) were urban residents and 13,625 (M: 6413; W: 7212) were rural-to-urban migrants. Compared to urban men, the mean±SD age was higher for rural-to-urban migrant men (32.80±10.85 vs 34.44±11.02; p=<0.001). Similarly, rural-to-urban migrants were older than urban women (31.20±10.38 vs 30.79±10.46; p=0.02). In the case of education, the percentage of school attendance was significantly higher for urban residents than rural-to-urban migrants. Among females, only two-third migrants (60.9%) attended school, compared to 72.9% of urban residents (p<0.001). The proportion of those who were currently married was higher for migrant women than urban women (82.9% vs 74.8%; p<0.001), whereas there was a higher proportion of never married urban women compared to migrant women (15.4% vs 6.4%; p<0.001). Among males, the overall pattern was similar to that for females. Most of the men were currently employed but the proportion was higher for migrants than urban residents (93.4% vs 88.1%; p<0.001). Women were far less likely than men to be currently employed and the proportions of women currently working was lower in urban than migrant women (24.0% vs 34.6%; p<0.001).

The proportion of rural-to-urban migrants was highest in Dhaka followed by Chittagong, compared to the other four divisions. More than half of the migrants lived in a slum neighbourhood in City Corporation (M: 56.2%; W: 55.0%). On the other hand, the majority of urban residents were living in a non-slum neighbourhood in City Corporation (M: 43.7%; W: 42.7%).

Among men, the two lowest household wealth quintiles contained half (50.6%) of rural-to-urban migrants, and the two wealthiest quintiles accounted for nearly half (45%) of urban residents ($p<0.001$). Almost equal proportion (≈19%) of migrant and urban residents were in the middle (or third) quintile. A nearly similar distribution was found for women. For monthly income, 27.7% urban men were in the highest quartile whereas 22.0% of migrants were in the highest quartile. This pattern was similar for women.

Table 2. 2: Study population characteristics by sex and place of origin

Study Population Characteristics	Men (n=13691)			Women (n= 14101)		
	Urban Non-migrants	Rural-to-urban migrants	p	Urban Non-migrant	Rural-to-urban migrants	p
n (%)	**7278 (53.2)**	**6413 (46.8)**		**6889 (48.9)**	**7212 (51.1)**	
Age (y), n (%)						
≤20	922 (12.7)	680 (10.6)	<0.001	1296 (18.8)	1237 (17.2)	0.004
21-30	2751 (37.8)	2125 (33.1)		2526 (36.7)	2570 (35.6)	
31-40	1755 (24.1)	1607 (25.1)		1716 (24.9)	1952 (27.1)	
>40	1850 (25.4)	2001 (31.2)		1351(19.6)	1453 (20.1)	
Ever attended school, n (%)	5943 (81.7)	4596 (71.7)	<0.001	5020 (72.9)	4392 (60.9)	<0.001
Highest Grade of Education, n (%)						
Primary level	1538 (21.1)	1565 (24.4)	<0.001	1586 (23.0)	1922 (26.7)	<0.001
High school level	3512 (48.3)	2505 (39.1)		2981 (43.3)	2281 (31.6)	
University level	893 (12.3)	526 (8.2)		453 (6.6)	189 (2.6)	
Marital status, n (%)						
Currently married	4750 (65.3)	4932 (76.9)	<0.001	5153 (74.8)	5980 (82.9)	<0.001
Never married	2479 (34.1)	1450 (22.6)		1063 (15.4)	465 (6.4)	
Others (Separated/divorced/ descended/ widow)	49 (0.7)	31 (0.5)		673 (9.8)	767 (10.6)	
Muslim Religion, n (%)	6462 (88.8)	5807 (90.6)	<0.001	6289 (91.3)	6506 (90.2)	0.015
Currently employed, n (%)	6411 (88.1)	5991 (93.4)	<0.001	1653 (24.0)	2497 (34.6)	<0.001
Division (administrative region in alphabetic order)						
Barisal	461 (6.3)	187 (2.9)	<0.001	463 (6.7)	266 (3.7)	<0.001
Chittagong	2046 (28.1)	1796 (28.0)		1978 (28.7)	1993 (27.6)	
Dhaka	2359 (32.4)	3255 (50.8)		2280 (33.1)	3232 (44.8)	
Khulna	1053 (14.5)	654 (10.2)		973 (14.1)	906 (12.6)	
Rajshahi	1071 (14.7)	225 (3.5)		954 (13.8)	462 (6.4)	
Sylhet	288 (4.0)	296 (4.6)		241 (3.5)	353 (4.9)	
Domains						
Slum neighbourhood in City Corporation	2838 (39.0)	3602 (56.2)	<0.001	2808 (40.8)	3965 (55.0)	<0.001
Non-slum neighbourhood in City Corporation	3181 (43.7)	2420 (37.7)		2945 (42.7)	2561 (35.5)	
District municipalities	1259 (17.3)	391 (6.1)		1136 (16.5)	686 (9.5)	
Household wealth Quintile						
Q1 (Poorest)	1275 (17.5)	1796 (28.0)	<0.001	1244 (18.1)	2207 (30.6)	<0.001
Q2	1318 (18.1)	1452 (22.6)		1208 (17.5)	1599 (22.2)	
Q3	1412 (19.4)	1262 (19.7)		1303 (18.9)	1243 (17.2)	
Q4	1783 (24.5)	1070 (16.7)		1575 (22.9)	1148 (15.9)	
Q5 (Richest)	1490 (20.5)	833 (13.0)		1559 (22.6)	1015 (14.1)	
Total income during last month of employed, Quartile						
Q1	1651 (26.4)	1431 (24.1)	<0.001	508 (31.4)	609 (24.7)	<0.001
Q2	1440 (23.1)	1586 (26.7)		337 (20.8)	607 (24.6)	
Q3	1423 (22.8)	1616 (27.2)		316 (19.5)	700 (28.4)	
Q4	1730 (27.7)	1308 (22.0)		457 (28.2)	547 (22.2)	

Results are expressed as number (%); X^2test was performed

The general health related characteristics of the study groups are presented in Table 2.3. A higher percentage of migrants (M: 10.3%; W: 17.4%) reported being unhealthy than urban residents (M: 7.9%; W: 14.2%). About one-fifth of rural-to-urban migrant men and women (18.3% and 21.6%, respectively) reported experiencing serious illness in the previous year and these proportions were higher compared to non-migrant urban men and women (15.2% and 18.4%, respectively). Overall, migrant men (8.3%) reported slightly higher levels of injuries in the last year than urban men (7.5%) ($p=0.035$) but there was no difference between the two groups among women.

Health related functional difficulties in the past four weeks were higher among migrants (M: 20.9% vs 16.7%; W: 20.0% vs 17.2%; $p<0.001$ for both comparisons). The ADL items were asked only if the respondents gave a positive answer to the health related functional difficulties question. Rural-to-urban migrants were more likely to report limitation for each ADL than non-migrant urban residents; however, the difference was not statistically significant.

Table 2. 3: General health related characteristics of the study participants by gender and place of origin

General health related Characteristics	Men (n=13691)			Women (n= 14101)		
	Urban Non-migrants	Rural-to-urban migrants	p	Urban Non-migrants	Rural-to-urban migrants	p
n (%)	**7278 (53.2)**	**6413 (46.8)**		**6889 (48.9)**	**7212 (51.1)**	
Self-reported general health condition, n (%)						
Healthy	3060 (42.0)	2176 (33.9)	<0.001	2145 (31.1)	1753 (24.3)	<0.001
Somewhat healthy	3641 (50.0)	3575 (55.7)		3766 (54.7)	4205 (58.3)	
Somewhat unhealthy	538 (7.4)	605 (9.4)		872 (12.7)	1103 (15.3)	
Unhealthy	39 (0.5)	57 (0.9)		106 (1.5)	151 (2.1)	
Had health related functional difficulties in past 4 wks., n (%)	1218 (16.7)	1339 (20.9)	<0.001	1186 (17.2)	1439 (20.0)	<0.001
i. personal care ADL	412 (5.7)	475 (7.4)	0.20	787 (11.4)	972 (13.5)	0.27
ii. motion ADL	542 (7.4)	629 (9.8)	0.11	933 (13.5)	1130 (15.7)	0.48
iii. strength/ mobility ADL	1016 (14.0)	1110 (17.3)	0.38	1147 (16.6)	1409 (19.5)	0.037
Serious illness in last year, n (%)	1108 (15.2)	1175 (18.3)	<0.001	1271 (18.4)	1558 (21.6)	<0.001
Serious injury in last year, n (%)	543 (7.5)	533 (8.3)	0.035	344 (5.0)	395 (5.5)	0.106

Results are expressed as number (%); X^2 was performed
ADL – activities of daily living

2.4.2 CVD risk factors and migration status

Table 2.4. presents the distribution of CVD risk factors by migration status among men and women. A slightly higher prevalence of cigarette smoking was reported by non-migrant urban men (49.3% vs 48.5%; p=0.17) whereas bidi smoking was higher in rural-to-urban migrants (10.7% vs 5.6%; p<0.001). A lower prevalence of alcohol intake was found in migrant than non-migrant urban residents (9.5% vs 14.7%; p<0.001).

Undernutrition (BMI 18.5) was more common among rural-to-urban migrants (M: 29.1%; W: 23%) than non-migrant urban residents (M: 10.3%; W: 17.4%). By contrast, overweight and obesity prevalence was markedly higher in the non-migrant urban group. The prevalence was the highest in urban women (42.8%) and the lowest in rural-to-urban migrant men (20.7%). Diabetes was almost similar among both migrant and urban men (10.9% vs 10.8%; respectively). In women, diabetes was more common in non-migrant urban residents (13.3%) than migrants (10.1%); however, the difference was not significant. Nearly half (46.3%) of non-migrant urban women and 39.9% of rural-to-urban migrant women had hypertension (p=0.016). Among men, the corresponding rates were lower and quite similar between the groups (35.5% for non-migrant urban and 32.7% for migrants; p=0.29). The highest proportion of probable cases of mental health disorder was found among rural-to-urban migrant women (35.9%) and the lowest in non-migrant urban men (16.8%).

Table 2. 4: Univariate associations between risk factors for cardiovascular disease and migration status

Risk factors	Men (n=13691)			Women (n= 14101)		
	Urban Non-migrants	Rural-to-urban migrants	p	Urban Non-migrants	Rural-to-urban migrants	p
Smoking and alcohol intake, n (%)	**n=7278**	**n=6413**		**n=1063**	**n=465**	
Cigarette smoking in last 1 month	3590 (49.3)	3110 (48.5)	0.17	8 (0.1)	0 (0)	-
Bidi smoking in last 1m	411 (5.6)	685 (10.7)	<0.001	0 (0)	0 (0)	-
Ever used alcohol	1068 (14.7)	609 (9.5)	<0.001	4 (0.1)	1 (0.1)	-
Anthropometry, n (%)	**n=3346**	**n=3246**		**n=3135**	**n=3539**	
Underweight	875 (26.2)	945 (29.1)		533 (17.0)	814 (23.0)	
Normal weight	1522 (45.5)	1628 (50.2)		1261 (40.2)	1553 (43.9)	
Overweight	450 (13.4)	335 (10.3)	<0.001	427 (13.6)	408 (11.5)	<0.001
Obesity	499 (14.9)	338 (10.4)		914 (29.2)	764 (21.6)	
Blood glucose, n (%)	**n=515**	**n=641**		**n=445**	**n=644**	
IFG	30 (5.8)	29 (4.5)	0.60	21 (4.7)	29 (4.5)	
Diabetes	56 (10.9)	69 (10.8)		59 (13.3)	65 (10.1)	0.26
Blood pressure, n (%)	**n= 597**	**n= 762**		**n=499**	**n=706**	
Hypertension	212 (35.5)	249 (32.7)	0.29	231 (46.3)	282 (39.9)	0.016
Mental health disorder, n (%)	**n= 7278**	**n= 6413**		**n= 6889**	**n= 7212**	
Probable case	1226 (16.8)	1226 (19.1)	<0.001	2266 (32.9)	2587 (35.9)	<0.001

Results are expressed as number (%); $X^2$and t-test was performed

Socioeconomic, migration status and CVD risks

The gender-specific crude associations between migration status, education level and household wealth and each CVD risk factor are presented in Annexure 2.2. Among men, the crude associations between migration status and the covariates were significant only for obesity (OR=0.66, 95% CI:0.59-0.74) mental health disorder (OR=1.17, 95% CI:1.07-1.27), bidi smoking (OR=1.99, 95% CI:1.76-2.27) and alcohol (OR=0.61, 95% CI:0.55-0.68). Among women, the crude associations were significant for obesity (OR=0.66, 95% CI:0.60-0.73), hypertension (OR=0.77, 95% CI:0.61-0.97), and mental health (OR=1.14, 95% CI:1.06-1.22). We further presented the association between education alone and household wealth and each CVD risk. For men, both education and household wealth were associated with obesity, smoking and alcohol consumption suggesting they may confound the association. The Mantel Haenszel odds ratios (adjusted once for education and once for HH wealth) were calculated to estimate the percent changes to the crude associations. Among men, both education and household wealth attenuated the association of migration status with obesity and smoking, and enhanced the association with alcohol consumption, whereas among women all the associations between migration status and CVD risk were attenuated. After adjustment for either education or household wealth, hypertension, diabetes and mental health status were no longer significantly associated with migration status (Annexure 2.2). These findings suggest that SES indicators were important factors in explaining the association between migration status and CVD.

Table 2.5 shows that an SES gradient, adjusted for age, exists both in migrants and life-long urban residents. The risk of overweight and obesity, hypertension and diabetes increased with the increasing of SES whereas for mental health disorders, alcohol consumption, cigarette and bidi smoking the reverse was found with the risks lower with increasing of SES status, regardless of migration status in both men and women.

Table 2. 5: Association between socio-economic status and CVDs risk factors among rural-to-urban migrant and urban resident

Risk Factors	SES	Men		Women	
		Urban Non-migrants	Rural-to-urban migrant	Urban Non-migrants	Rural-to-urban migrant
Overweight & obesity	**Education** [a]				
	Illiterate	Ref	Ref	Ref	Ref
	Primary	1.24 (0.89-1.74)	1.40 (0.99-1.97)	1.54 (1.22-1.96)	1.44 (1.17-1.79)
	High school and above	2.46 (1.83-3.31)	2.94 (2.15-4.02)	1.54 (1.21-1.96)	1.68 (1.33-2.13)
	HH Wealth Quintile [b]				
	Q1 (Poorest)	Ref	Ref	Ref	Ref
	Q2	1.08 (0.72-1.61)	1.71 (1.17-2.51)	1.47 (1.08-2.01)	1.38 (1.07-1.78)
	Q3	2.13 (1.50-3.04)	2.89 (2.01-4.16)	2.40 (1.79-3.21)	3.21 (2.50-4.12)
	Q4	3.65 (2.60-5.13)	5.76 (4.00-8.30)	3.49 (2.60-4.69)	4.15 (3.16-5.44)
	Q5 (Richest)	5.55 (3.91-7.87)	9.49 (6.52-13.82)	6.11 (4.47-8.35)	7.60 (5.70-10.15)
Hypertension	**Education** [a]				
	Illiterate	Ref	Ref	Ref	Ref
	Primary	0.99 (0.57-1.74)	1.58 (1.01-2.49)	1.60 (0.95-2.69)	0.86 (0.56-1.34)
	High school and above	1.26 (0.75-2.10)	2.28 (1.42-3.66)	1.28 (0.74-2.22)	0.74 (0.44-1.24)
	HH Wealth Quintile [b]				
	Q1 (Poorest)	Ref	Ref	Ref	Ref
	Q2	1.12 (0.50-2.52)	1.23 (0.73-2.08)	0.66 (0.29-1.51)	1.06 (0.63-1.79)
	Q3	2.59 (1.24-5.41)	1.73 (1.03-2.91)	0.83 (0.38-1.82)	1.76 (1.04-2.96)
	Q4	3.02 (1.47-6.19)	1.56 (0.89-2.74)	1.60 (0.77-3.32)	4.05 (2.31-7.08)
	Q5 (Richest)	2.96 (1.40-6.23)	1.72 (0.98-3.03)	2.13 (0.96-4.72)	4.04 (2.26-7.24)
Diabetes	**Education** [a]				
	Illiterate	Ref	Ref	Ref	Ref
	Primary	0.84 (0.24-2.96)	0.98 (0.37-2.64)	2.14 (0.88-5.21)	0.68 (0.31-1.52)
	High school and above	2.00 (0.73-5.52)	2.30 (0.93-5.70)	1.46 (0.60-3.57)	1.04 (0.47-2.27)
	HH Wealth Quintile [b]				
	Q1 (Poorest)	Ref	Ref	Ref	Ref
	Q2	1.04 (0.16-6.59)	1.45 (0.47-4.49)	0 (0-0)	1.76 (0.46-6.74)
	Q3	1.20 (0.20-7.06)	1.80 (0.59-5.50)	2.14 (0.23-20.17)	4.79 (1.46-15.65)
	Q4	3.19 (0.65-15.63)	2.25 (0.74-6.82)	4.92 (0.61-39.84)	3.88 (1.09-13.74)
	Q5 (Richest)	3.62 (0.73-18.03)	3.60 (1.24-10.41)	8.60 (1.04-71.43)	10.48 (3.14-34.90)

Table 2.5 (continue)

Risk Factors	SES	Men		Women	
		Urban Non-migrants	Rural-to-urban migrant	Urban Non-migrants	Rural-to-urban migrant
Mental health disorder	**Education** [a]				
	Illiterate	Ref	Ref	Ref	Ref
	Primary	1.01 (0.84-1.20)	0.86 (0.73-1.01)	0.83 (0.72-0.96)	0.93 (0.82-1.06)
	High school and above	0.72 (0.60-0.86)	0.69 (0.58-0.82)	0.64 (0.55-0.75)	0.64 (0.55-0.74)
	HH Wealth Quintile [b]				
	Q1 (Poorest)	Ref	Ref	Ref	Ref
	Q2	0.87 (0.72-1.04)	0.73 (0.62-0.87)	0.93 (0.79-1.09)	0.86 (0.75-0.98)
	Q3	0.66 (0.54-0.80)	0.68 (0.56-0.82)	0.87 (0.74-1.03)	0.83 (0.72-0.97)
	Q4	0.50 (0.40-0.61)	0.53 (0.42-0.67)	0.58 (0.49-0.69)	0.55 (0.46-0.66)
	Q5 (Richest)	0.42 (0.33-0.53)	0.42 (0.32-0.55)	0.43 (0.36-0.53)	0.43 (0.35-0.53)
Cigarette smoking	**Education** [a]				
	Illiterate	Ref	Ref	-	-
	Primary	1.05 (0.90-1.22)	0.90 (0.79-1.04)		
	High school and above	0.88 (0.76-1.01)	0.54 (0.47-0.63)		
	HH Wealth Quintile [b]				
	Q1 (Poorest)	Ref	Ref		
	Q2	0.88 (0.75-1.03)	1.08 (0.93-1.24)		
	Q3	0.79 (0.66-0.91)	1.10 (0.94-1.28)	-	-
	Q4	0.64 (0.54-0.75)	0.71 (0.60-0.85)		
	Q5 (Richest)	0.58 (0.49-0.69)	0.63 (0.52-0.76)		
Bidi smoking	**Education** [a]				
	Illiterate	Ref	Ref	-	-
	Primary	0.65 (0.50-0.82)	0.58 (0.48-0.72)		
	High school and above	0.28 (0.21-0.38)	0.34 (0.26-0.44)		
	HH Wealth Quintile [b]				
	Q1 (Poorest)	Ref	Ref		
	Q2	0.56 (0.44-0.73)	0.44 (0.36-0.54)		
	Q3	0.36 (0.27-0.49)	0.22 (0.16-0.29)	-	-
	Q4	0.13 (0.08-0.20)	0.08 (0.05-0.14)		
	Q5 (Richest)	0.02 (0.01-0.06)	0.02 (0.01-0.07)		
Alcohol intake	**Education** [a]				
	Illiterate	Ref	Ref	-	-
	Primary	0.89 (0.73-1.09)	1.15 (0.92-1.43)		
	High school and above	0.81 (0.67-0.98)	0.76 (0.59-0.96)		
	HH Wealth Quintile [b]				
	Q1 (Poorest)	Ref	Ref		
	Q2	0.86 (0.70-1.06)	0.86 (0.68-1.07)		
	Q3	0.77 (0.62-0.95)	0.68 (0.53-0.88)	-	-
	Q4	0.65 (0.52-0.81)	0.69 (0.51-0.93)		
	Q5 (Richest)	0.72 (0.57-0.91)	0.82 (0.59-1.14)		

[a] Adjusted for current age and HH wealth quintile [b] Adjusted for current age and education
Lifestyles were not assessed in women as few women reported these behaviours

For most outcome, rural-to-urban migrants from high SES had similar or higher risk than urban non-migrants, suggesting that some excess risk for migrants is dependent on SES status.

We therefore examined interactions between SES (i.e., education levels and household wealth quintiles) and migration status on CVD risk factors and overall it seems to be higher risk in rural-to-urban migrants than their counterparts urban non migrants of the same SES status. Interaction was done on continuous variables to increase statistical power. While no significant interactions were observed in men, significant interactions in women were found between education and migration status on BMI (p=0.014) (Figure 2.3). Among women from a high education level, the differences in BMI between rural-to-urban migrants and lifelong urban residents were negligible whereas among women from lower education levels, the differences in BMI were substantial. In addition, marginal significant effects between household wealth and migration status for BMI (p=0.074), and education and migration status for glucose level (p=0.078) were observed. This may suggest that the migrants from high SES either carried their risk forward from rural to urban life or they first to be affected to adverse consequence of urban life on CVD metabolic risks.

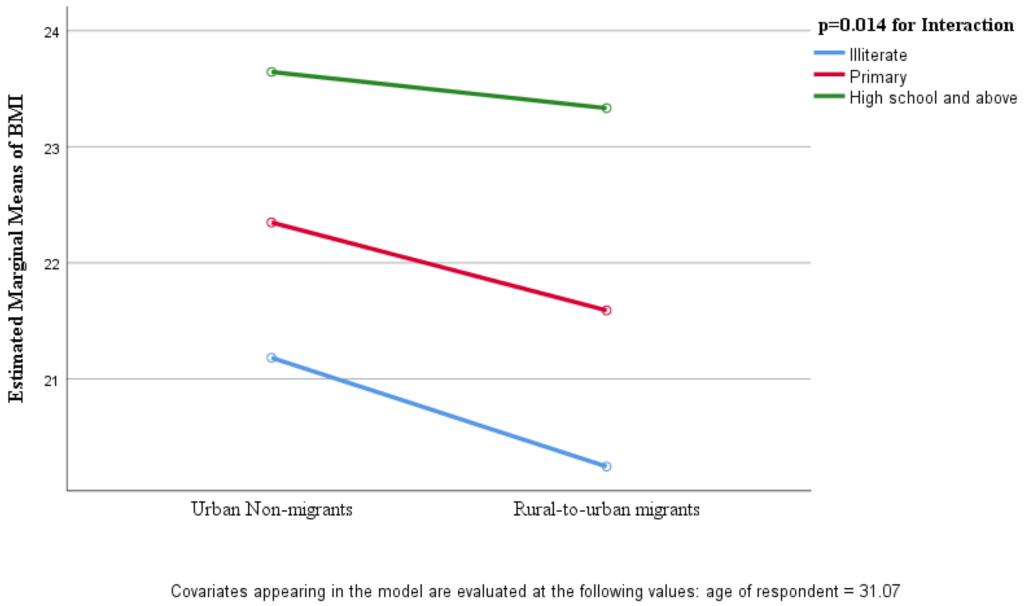


Figure 2. 3: Mean BMI of women by education and migration status

Table 2.6 shows the adjusted association of migration status with CVD risk factors by years of exposure to urban life. As this study had only the urban group for comparison rather than the origin population, it was not possible to estimate how much of the risk could be attributed to migration alone. Therefore, we have stratified recent migrants and long term migrants by years since migration.

Migration status was stratified using median value by years since migration (M:≤12 yr vs >12 yr; W:≤10 yr vs >10 yr). In the multivariate logistic regression analysis, among men most risk factors were higher in longer term migrants (>12 yr) and were highest in urban men compared to the recent migrant men (≤12 yr). However, bidi smoking and diabetes were an exception, showing a reverse gradient. Though odds of cigarette smoking was highest in urban men (OR = 1.42, 95% CI: 1.27-1.59 and OR=1.49, 95% CI: 1.36-1.64), bidi smoking in urban men was significantly lower than in migrant men (OR=0.56, 95% CI: 0.46-0.68 and OR=0.53, 95% CI: 0.44-0.64). Compared to recent migrant women (≤10 yr), longer term migrants (>10 yr) and urban women were more likely to be overweight and obese (OR=1.44, 95% CI: 1.22-1.71 and OR=1.48, 95% CI: 1.29-1.71], and had common mental health disorder (OR =1.29, 95% CI:1.15-1.43) and 1.24 (1.13-1.37)]. There was no effect of duration since migration on hypertension, (OR = 1.10, 95% CI: 0.76-1.59 and OR=1.10, 95% CI 0.75-1.60) which may be due to chance. The risk of diabetes was 32% and 25% lower among long term migrant and urban residents than recent migrants, but again it cannot be ruled out that it is due to chance.

Table 2. 6: The adjusted association of migration status with cardiovascular diseases risk factors

Risk Factors	Men			Women		
	OR (95% CI)			OR (95% CI)		
	Recent Migrant	Longer term Migrant	Urban resident	Recent Migrant	Longer term Migrant	Urban resident
Cigarette smoking	Ref	1.42 (1.27- 1.59)	1.49 (1.36- 1.64)	-		
Bidi smoking	Ref	0.56 (0.46- 0.68)	0.53 (0.44- 0.64)	-		
Alcohol intake	Ref	1.97 (1.63-2.37)	2.55 (2.17-3.00)	-		
Overweight & obesity	Ref	1.23 (1.00- 1.53)	1.35 (1.12- 1.62)	Ref	1.44 (1.22-1.71)	1.48 (1.29- 1.71)
Mental health disorder	Ref	1.01 (0.88- 1.17)	1.04 (0.92- 1.17)	Ref	1.29 (1.15-1.43)	1.24 (1.13-1.37)
Hypertension	Ref	1.21 (0.83- 1.78)	1.25 (0.85- 1.85)	Ref	1.10 (0.76-1.59)	1.10 (0.75-1.60)
Diabetes	Ref	0.97 (0.50- 1.90)	0.88 (0.44- 1.74)	Ref	0.681 (0.36-1.28)	0.761 (0.41-1.43)

Adjusted for current age, attended school, working currently, marital status, domain of residence, division, monthly income, HH wealth quintile

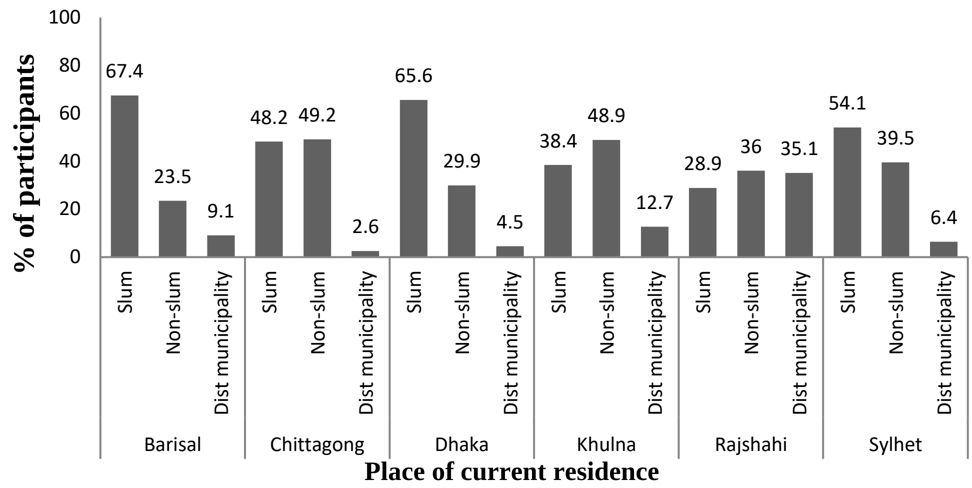
2.4.3 CVD risk factors and migration indicators

Figure 2.4 (men) and 2.5 (women) demonstrate the characteristics of migration among rural-to-urban migrants. Median (Q1; Q3) duration of stay in the current place location for men and women were 12 yrs (5; 20) and 10 yrs (4; 18), respectively. Women in slums were more likely to report the shortest duration of stay than non-slum women in all divisions except Barishal and Khulna. On the other hand, the pattern was quite the opposite for men, which indicated women were more likely to be 'recent arrivals' than men. Most of the men migrated for work or their own education or work related reason, regardless of slum and non-slum. By contrast, the main reason for migration in women was familial reasons such as marriage or children's education.

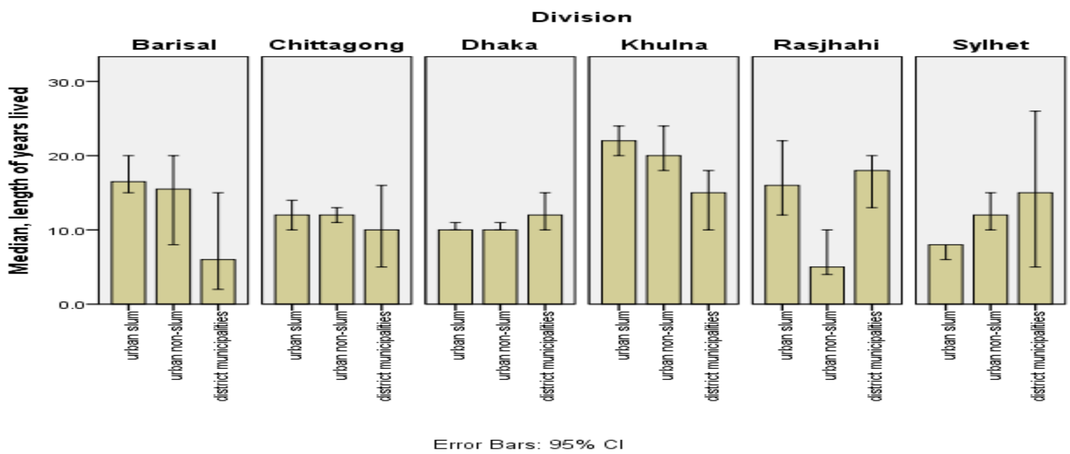
Table 2.7 shows migration indicators associated with CVD risk factors among migrants only, adjusting for a range of confounders. Consistent increasing pattern of risk was observed with longer duration of urban stay in migrant men (p for trend=0.007 for obesity and <0.001 for smoking and alcohol intake), apart from diabetes, hypertension and mental health disorder. A longer period of residence in an urban area was associated with more cigarette smoking, whereas bidi smoking decreased with length of urban stay. Among women, those with a longer period living in an urban area had higher odds of overweight and obesity, and mental health disorder (p_{trend}<0.001). In both men and women, migrating for work or education (rather than any other reasons) was associated with higher likelihood of hypertension [OR 0.83 (0.69, 0.99) and OR 0.83 (0.69, 0.99), respectively].

Figure 2. 4: Characteristics of migration among rural-to-urban migrant men

2.4a: Distribution of rural-to-urban migrants by place of residency



2.4b: Length of years lived in urban



2.4c: Reasons for migration

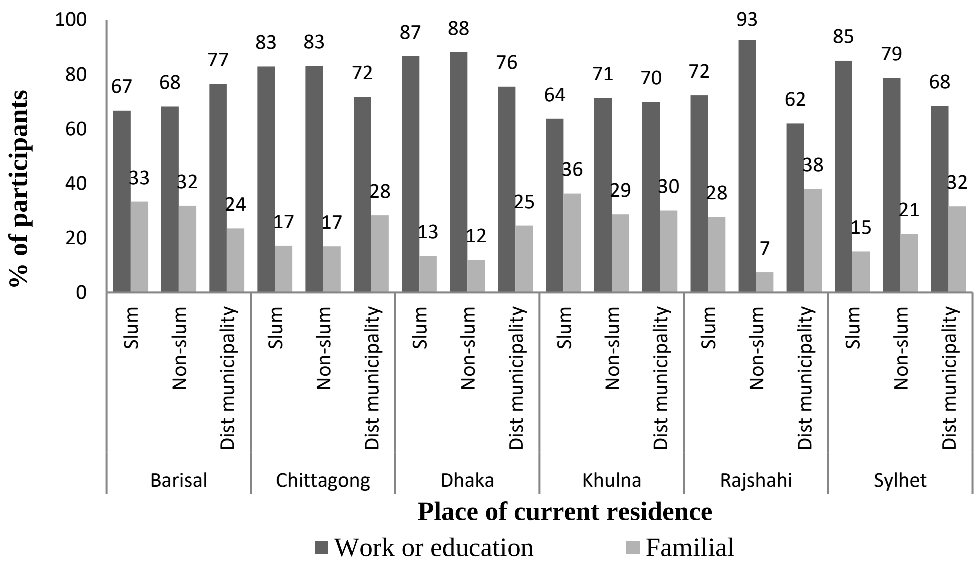
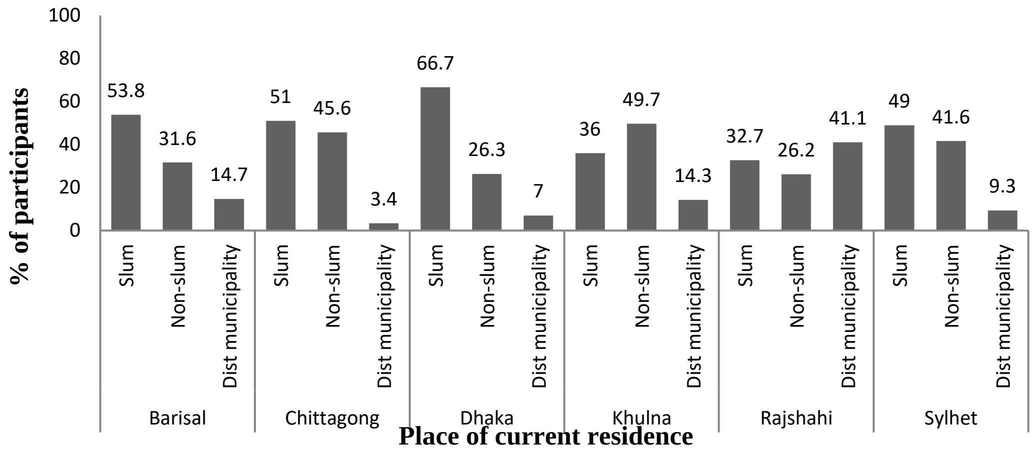
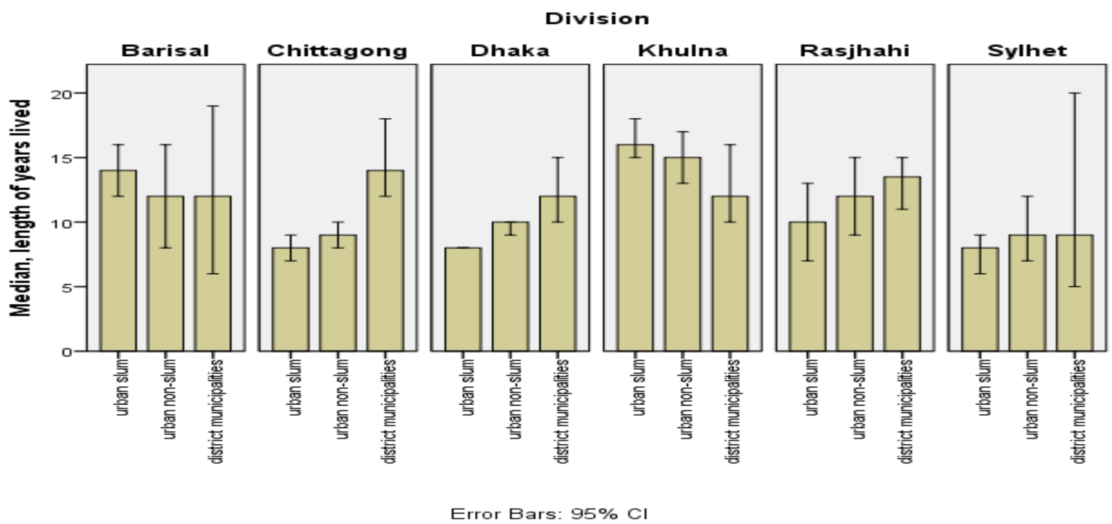


Figure 2. 5: Characteristics of migration among rural-to-urban migrant women

2.5a: Distribution of rural-to-urban migrants by place of residence



2.5b: Length of years lived in urban



2.5c: Reasons for migration

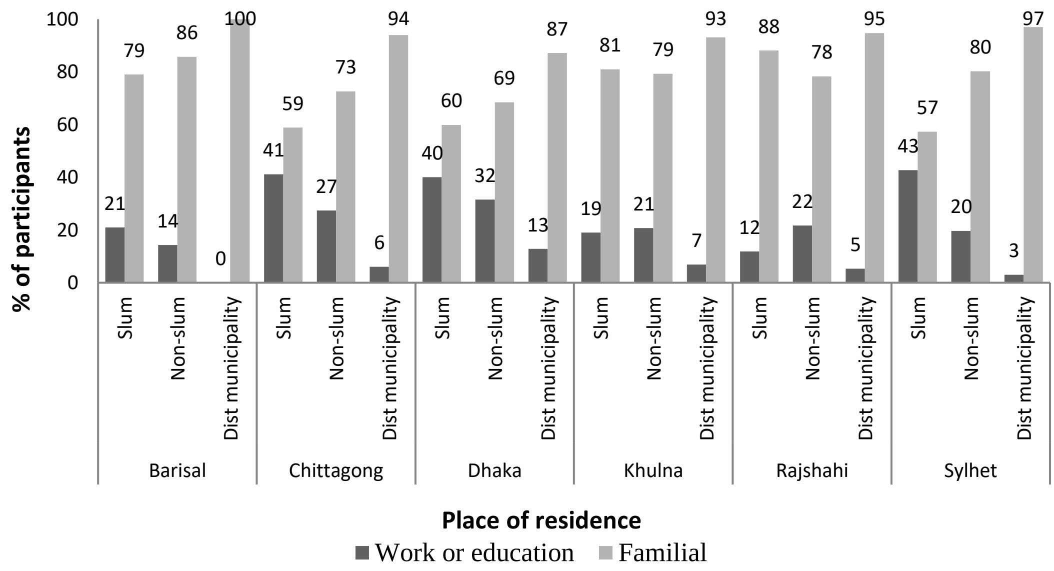


Table 2. 7: Length of urban years and reasons for migration and their association with CVD risk factors among rural-to-urban migrant men and women

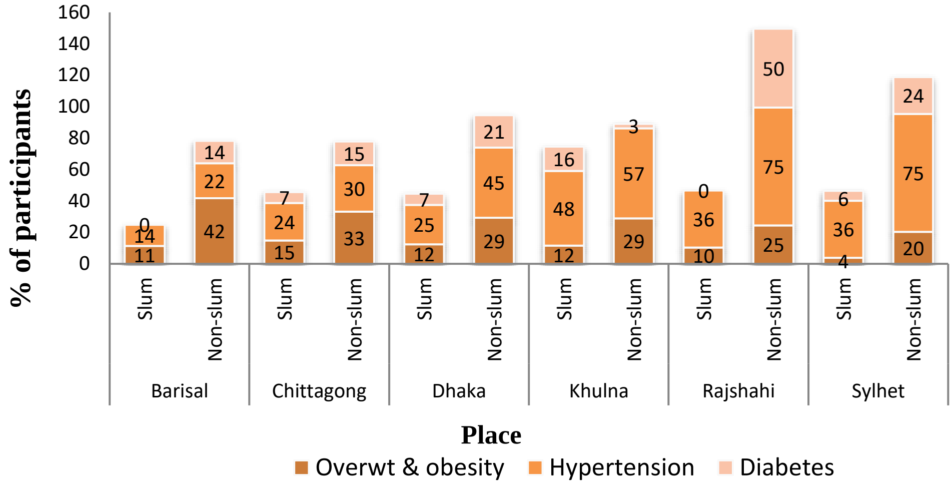
Variables	Risk Factors						
	Overweight and obesity	**Mental health disorder**	**Hypertension**	**Diabetes**	**Cigarette smoking**	**Bidi smoking**	**Alcohol intake**
	Adjusted OR (95% CI)						
Men (n=6413)							
Length of years lived							
Q1 (≤5 years)	ref	ref	ref	ref	ref	ref	ref
Q2 (6-12 years)	1.20 (0.87- 1.64)	1.02 (0.85- 1.24)	1.26 (0.66- 2.43)	0.82 (0.26- 2.58)	1.15 (0.99- 1.34)	0.68 (0.53- 0.87)	1.47 (1.11-1.96)
Q3 (13-20 years)	1.32 (0.94- 1.84)	0.98 (0.80- 1.20)	1.10 (0.59- 2.01)	0.55 (0.18- 1.63)	1.40 (1.20- 1.64)	0.54 (0.42- 0.70)	2.21 (1.66- 2.95)
Q4 (>20 years)	1.67 (1.15- 2.41)	1.08 (0.86- 1.36)	1.58 (0.88- 2.82)	1.22 (0.47- 3.16)	1.67 (1.40- 2.02)	0.40 (0.29- 0.53)	2.86 (2.04- 4.00)
p for Trend	0.007	0.66	0.13	0.45	<0.001	<0.001	<0.001
Reason for migration							
Migration for family, marriage and other	ref	ref	ref	ref	ref	ref	ref
Migrated for work, employment & education	1.23 (0.91- 1.65)	1.06 (0.87- 1.29)	1.04 (1.01- 1.07)	1.10 (0.49- 2.46)	0.94 (0.80- 1.20)	1.23 (0.93- 1.64)	0.66 (0.53- 0.83)
Women (n= 7212)							
Length of years lived							
Q1 (≤4 years)	ref	ref	ref	ref			
Q2 (5-10 years)	1.20 (0.96- 1.51)	0.99 (0.86- 1.14)	1.59 (0.84- 3.01)	0.52 (0.18- 1.51)	-	-	-
Q3 (11-18 years)	1.53 (1.20- 1.95)	1.28 (1.10- 1.49)	0.95 (0.53- 1.71)	0.19 (0.06- 0.62)			
Q4 (>19 years)	1.74 (1.32- 2.30)	1.35 (1.13- 1.60)	1.40 (0.81- 2.41)	0.74 (0.32- 1.70)			
p for Trend	<0.001	<0.001	0.46	0.79			
Reason for migration							
Migration for family, marriage and other	ref	ref	ref	ref	-	-	-
Migrated for work, employment & education	0.87 (0.71- 1.10)	1.10 (0.96- 1.23)	2.07 (1.34- 3.18)	0.90 (0.41- 1.70)			

2.4.4 CVD risk factors and environment - urban area of residency

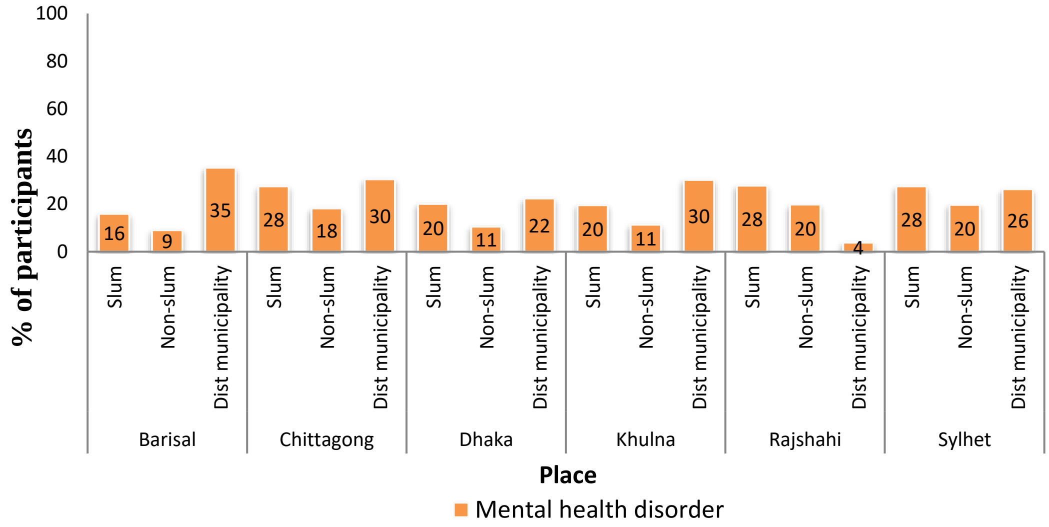
Our third objective was to find out whether CVD risk factors varied by place of residence. Here we took six divisions and three domains including slum, non-slum and District Municipalities. Figure 2.6 (men) and 2.7 (women) present the distribution of risk factors by place of residence. For both men and women, overweight and obesity, and hypertension were higher in non-slum than slum areas in most of the divisions. Almost the same pattern was found for diabetes. In the case of mental health disorders, the proportion of probable cases was higher in slum and District Municipalities than non-slum areas. Women had a higher number of probable cases of mental health disorders. Nearly half of the men in slum areas were current cigarette smokers and the proportion was higher than their non-slum and District Municipality counterparts. Bidi smoking was much lower than that of cigarette smoking. Men in slums and District Municipalities were much more likely to report smoking bidi than non-slum counterparts.

Figure 2. 6: Distribution of CVD risk factors according to current place of residence among rural-to-urban migrant men

2.6a: Distribution of overweight and obesity, hypertension and diabetes



2.6b: Distribution of mental health disorder



2.6c: Distribution of smoking and alcohol intake

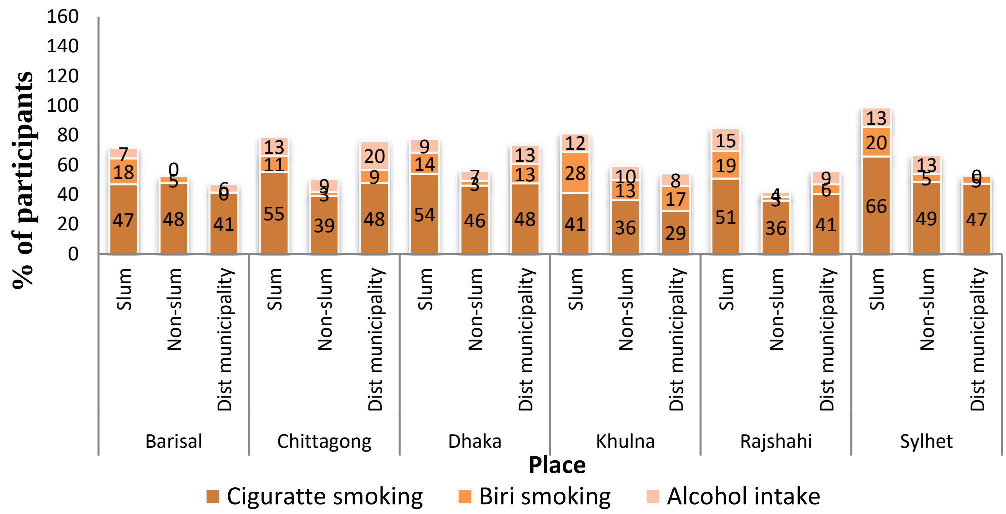
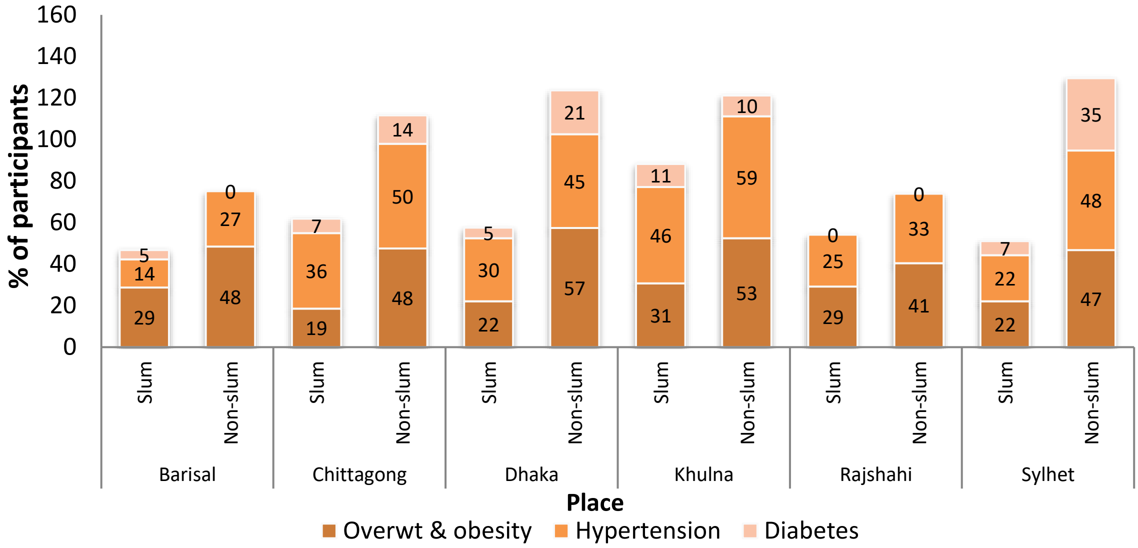
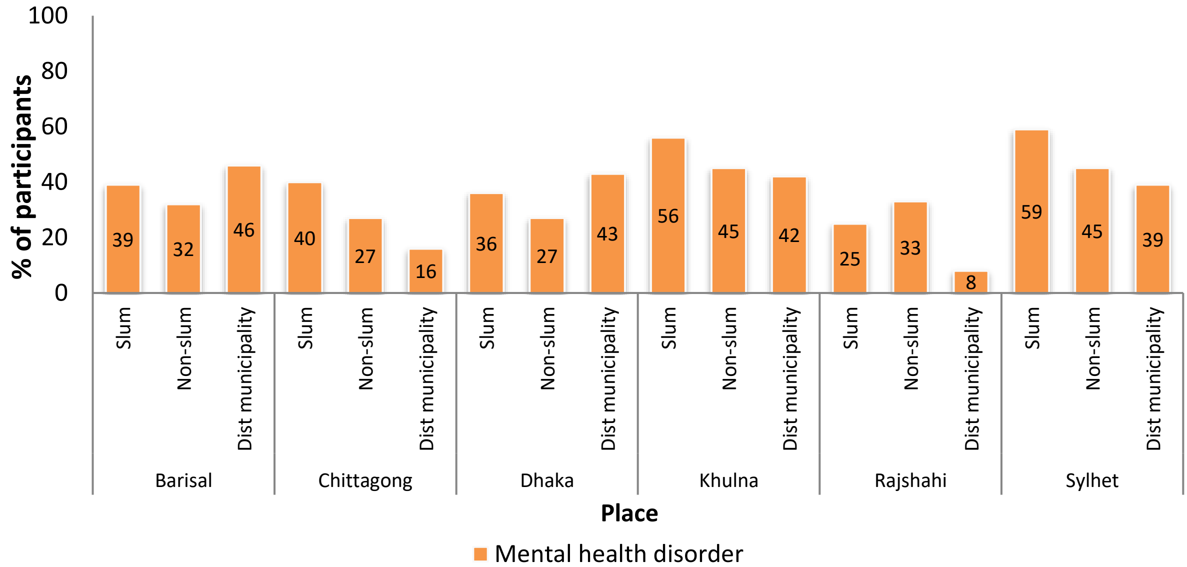


Figure 2. 7: Distribution of CVD risk factors according to current place of residence among rural-to-urban migrant women

2.6a: Distribution of overweight & obesity, hypertension and diabetes



2.6b: Distribution of mental health disorder



2.5 Discussion

Bangladesh has been experiencing rapid urbanisation for the past few decades, caused mainly by rural-to-urban migration (174). This raises the concern that the chronic disease burden might be high in migrants due to adaptation of an unhealthy lifestyle. Most of the studies on migration in Bangladesh have focused on reasons or determinants of migration (174, 175), socio-economic characteristics of migrants (127, 176) or reproductive health (177). To the best of our knowledge this is the first study to look at the relationship between internal migration from rural areas to the cities and CVD risk factors among the Bangladeshi population.

This study compared two groups; migrants from a rural-to-urban area and individuals who always lived in an urban area. For most of the CVD risk factors, the risk profile of migrants was lower than the risk profile of the urban group, except for bidi smoking and mental health disorder, which were higher in rural-to-urban migrants. Separate analyses selecting only migrants showed that levels of CVD risk factors gradually increased with a longer period of residency in urban area, after adjusting for multiple confounders. However, the pattern and magnitude of these changes varied across risk factors and gender. The proportion of CVD risk factors also varied by urban place of residence. Hypertension as well as overweight and obesity were more prevalent in non-slum than slum residents, whereas mental health disorder, and cigarette and bidi smoking were higher in slum areas and District Municipalities than non-slum areas.

2.5.1 CVD risk factors by migration status and the role of SES

Findings of this study complement the results of other studies (86, 178) on the impact of rural-to-urban migration where in most instances, CVD risk profiles were worse in urban residents than migrants, or similar in both groups. This might be explained by the upward mobility in socioeconomic indicators with studies suggesting that CVD risk factors such as dietary habits, physical activity, metabolic risk factors, social gradient and the country's Human Development Index (179-183), the greater the development the higher the risk.

Bangladesh has been undergoing transformation in its demographic, socio-economic and political structure and while these are considered as positive human developments, they apparently impact population health as reflected in disease transition from a higher number of communicable diseases to a higher proportion of non-communicable diseases (1, 174). Similar changes occurred in western countries about a hundred years ago. Initially, in a socioeconomically primitive society, CVD risk factors were higher in the high SES group before eventually transferring to the low SES group following social and economic development and ongoing epidemiological transition (91). While studies from developed countries currently show consistent patterns (a higher prevalence of CVD risk factors among people of lower SES) (91, 184), this pattern is reversed for developing countries (high SES groups experiencing higher CVD risk factors) (161, 183-186), though recently there has been debate about the direction of association (180, 184, 187) as discussed below.

The present study showed a positive association between SES and most of the CVD risk factors among both migrant and urban groups, i.e. the higher the SES, the higher the CVD risk. However, a negative association was found between cigarette and bidi smoking, and higher income and educational attainment among men, urban and migrant alike. Further, alcohol intake decreased with higher education and income, with the exception of the top wealth quintile, which could be an indicator of culture among those in the top economic and political leadership roles. By contrast, the risk of mental health disorders was higher in lower SES men and women compared to high SES individuals. This may indicate less financial and personal resources (e.g., education) to overcome hardship in the lower SES group, whereas the high SES group are more able to seek mental care or are equipped with educational resources to combat distress and hardship. The 2010 NCD risk factor survey in Bangladesh also reported that diabetes, hypertension, physical inactivity and obesity increased with socioeconomic achievements, though no data on mental health was collected (188). Another study of India showed a similar pattern with metabolic risk factors such as diabetes, hypertension, dyslipidemia and obesity were higher in high SES groups, whereas tobacco and alcohol use and being underweight were more prevalent in low SES individuals (189). However, this pattern may vary by place of residence. For example, another study in Bangladesh demonstrated that although hypertension, diabetes, and overweight/obesity were more prevalent among the richest, after stratification by place of residence, a high prevalence for these conditions was found among the wealthy in urban areas and the poor in rural areas (187). This paradoxical relationship between social gradients and behavioural, weight-related and metabolic risks indicates that an epidemiological transition may be ongoing (184).

Most of the migration held due to economic reasons and migration to urban often improves SES (180, 190). Forsdahl hypothesises that poverty followed by subsequent affluence may increase the risk of CVD risk (191). The Indian IMS also reported that individuals who shifted from a low SES to a current high SES experienced higher systolic BP, body fat percentage and Homeostatsis Model Assessment (HOMA) score, compared with those who were classified at low SES and remained at that level (180).

Another study on rural-to-urban migrants conducted in Peru showed that SES was the most significant predictor and positively associated with BMI among migrants (161).

In migrant study, the more appropriate comparison group with migrants is the origin population rather than host population (192). As this study had only urban group for comparison, it was not possible to estimate how much risk would be attributed to migration alone. Therefore, we have stratified recent migrants and long term migrants by years since migration and found a gradient of risk from recent migrants to long term migrants and urban dwellers. A similar pattern was found in a study conducted in India, where the prevalence rate of obesity and diabetes was the lowest in non-migrant rural dwellers, then in most recent migrants, followed by longer term migrants and the highest in non-migrant lifelong urban dwellers, with an evident weak linear trend (86).

2.5.1.1 Overweight and Obesity

Overweight and obesity was more prevalent in women than men, a phenomenon documented worldwide and supported by other studies in Bangladesh (139, 188). While the prevalence of being underweight was higher in migrants, the prevalence of being overweight or obese was lower among migrant than urban men and women. Another study from Bangladesh also showed that the prevalence of underweight was significantly higher among rural-to-urban migrant women than urban women, whereas this was the opposite in the case of overweight and obesity (193). Although the prevalence of overweight and obesity here was lower in migrants than non-migrant urban residents, it is important to highlight that the prevalence was not low; one-third and one-fourth of rural-to-urban migrant women and men were overweight and obese, respectively. Hence, this finding shows that Bangladesh is facing a double burden of underweight and overweight.

After adjustment for the significant impact of socioeconomic variables, urban residents and longer term migrants were more at risk of being overweight and obese than short term migrants in both men and women, supporting the transition of greater exposure to risks associated with urban life. Similar findings have been reported in a number of rural-urban migrant studies in India (75, 86), Peru (87), and Poland (194) where overweight and obesity were higher in rural-to-urban migrants than in lifelong rural residents but still lower than in urban residents. Whether most of the weight gain occurs in the earlier years of migration or creeps slowly over time, would be interesting to know, in particular to inform the potential urgency of early intervention.

2.5.1.2 Hypertension

Unlike overweight and obesity, hypertension did not follow any consistent pattern in different studies (74, 81). The present study also did not show any pattern among study groups. The prevalence of hypertension in this study was quite high in both groups (>30%) which is similar to another study conducted in urban area of Bangladesh reporting 23.7% (195). This may suggest that this is a common problem in Bangladesh. It was significantly higher among migrant women than urban women but not in men. A meta-analysis of population-based CVD risk factor studies in Bangladesh, synthesising data up to 2014, reported a pooled prevalence of 14% for hypertension (141). In the 2010 NCD risk factor survey (188), the prevalence was 18% which further increased to 21% in the follow up study in 2013 (139). However, the prevalence estimate of these studies included both rural and urban adult (>20 years) populations, suggesting that in rural areas the hypertension level is lower than in urban area whereas current study measured only urban adults over age 35 years.

2.5.1.3 Diabetes

The prevalence of diabetes found by the UHS was around 10%, which was higher than other studies (5-7%) in Bangladesh (139, 141, 196). No significant difference was observed between migrant and urban groups in both men and women. A scoping review on changing pattern of diabetes in Bangladesh, however, indicated an increasing trend of diabetes prevalence among urban and rural population at a rate of 0.05% and 0.06% per year, respectively (196). In this study one methodological limitation to measuring blood glucose level was that it was measured by fasting capillary blood glucose (FCBG). This measure is often used in epidemiological studies to determine the prevalence of diabetes, though it is not reliable for diagnosis of diabetes (197, 198). Therefore, there was always a chance of misclassification due to the inability to perform the more reliable oral glucose tolerance test (OGTT) or even fasting plasma glucose (FPG). Relatively few studies have investigated the impact of rural-to-urban migration on glucose level (81, 86, 87, 194, 199). The migrant study of India reported similar fasting blood glucose levels among migrant and urban groups (86). In contrast, glucose levels were found to be lower in the migrant than urban group in Peru (87) and Poland (194). The WHO study on global ageing and adult health (SAGE), conducted in six low-and-middle income countries on adults over 18 years old, demonstrated that the prevalence of doctor diagnosed diabetes was significantly higher in urban dwellers (RR 1.69, 95% CI: 1.15-2.47) followed by migrant groups, compared with rural groups in the pooled analysis. However, in the country-specific analysis, Ghana and Russia showed a higher prevalence in migrants than urban residents (81).

2.5.1.4 Smoking and alcohol intake

Cigarette smoking was more prevalent in urban dwellers than rural-to-urban migrants, whereas it was the reverse for bidi smoking, possibly due to the low cost of bidi making it more affordable for migrants. Bangladesh Global Adult Tobacco Survey (GATS) which was conducted in 2009 reported overall prevalence of current smokers was 23.0% and more among males (44.7%) than females (1.5%) (200). A systematic review also showed that the prevalence of smoking in Bangladesh was 37-63% among men and 5-7% among women (141). The present study reported a similar prevalence among men (49%) but very low prevalence among women (0.1%). This low prevalence in women was due to the fact that smoking is not a socially or culturally acceptable norm for women in Bangladesh and thus, discouraged for honest disclosure. On the other hand, women use smokeless tobacco with betel quid which is responsible for various NCDs (139). There are mixed findings of smoking behaviours in other studies; while some studies documented that migrant and urban groups are more likely to smoke than rural groups (201-203), other studies showed reverse findings (81, 86). Similar finding has been documented for alcohol intake in the present study. However, while the Peru migrant study showed heavy drinking in the past year was similar between the urban, migrant, and rural groups (201), the pool analyses of the WHO-SAGE study showed significantly lower alcohol consumption in urban and migrant groups compared to rural residents (81).

2.5.1.5 Common mental health disorders

Any kind of migration poses stress on migrants which compromises their mental health (204). One of the underlying reasons is the disruption to family life such as loss of support from family and social networks. Being separated from family and friends and facing stress in the adjustment process can increase the vulnerability to psychological illness (102, 204). The present study showed that women were more vulnerable than men to mental health disorders. The prevalence of probable cases was the highest in migrant women (35.9%) and the lowest in urban men (16.8%). A recent systematic review on mental health disorders in Bangladesh estimated an overall prevalence of 6.5 to 31% among adults, and suggested a higher prevalence of mental illness among women, urban residents and the poor (205). Mental illness has been disregarded in Bangladesh due to lack of knowledge, superstitious beliefs and social stigma, which inhibit women from seeking medical treatment (205, 206). In the present study, long term rural-to-urban migrant women as well as non-migrant urban women had 29% and 24% higher risk, respectively, of having a mental health disorder compared to more recent migrant women. Findings from a longitudinal study of rural-to-urban migrants in Thailand reported that migrants were mentally healthier upon arrival, nevertheless, their mental health deteriorated within two to four years after migration (101). Among men, although the prevalence was higher in rural-to-urban migrants (19%) than urban residents (16.8%), the risk was almost similar after adjusting for potential confounders. Similar findings were observed in the Peru migrant study where the prevalence of mental disorders was higher in migrants (38%) compared to urban individuals (33%), however, after adjustment for confounders the migrant group were not different to urban residents, though their analyses were not gender specific (207). The opposite scenario was documented in a study of Chinese rural-to-urban migrant workers migrants were healthier than their urban counterparts (208). These two possible directions observed for mental health trends indicate that the migration process is a complex phenomena, potentially dependent on the level of acculturation, as discussed below.

2.5.2 CVD risk factors by migration indicators

The findings of this study suggest that CVD risk factors increase with time spent in an urban area. However, the pattern and magnitude of these changes were not uniform and varied across risk factors and gender. In this study, we took length of urban residence as a proxy measure of acculturation, and weight gain as the immediate consequence of an adopting unhealthy diet and reducing physical activity, which are the results of the acculturation process.

Studies reported that unhealthy weight gain among migrants significantly increases after 10-15 years of migration (97). The current study demonstrated that the risk of overweight and obesity increased with each quartile of urban life exposure in both genders. The recent prospective Peru Migrant study followed migrants for five years after migration and reported that migrant and urban groups had an 8-to-9.5 times higher risk of developing obesity than the rural group (119). Another cross-sectional migrant study on CVD risk factors and duration of urban dwelling (conducted in India), also showed that adiposity increased rapidly within one decade after moving to an urban area, whereas other CVD risk factors such as blood pressure, and diabetes developed progressively up to the fourth decade (120). A longitudinal study in Thailand reported that hypertension and hyperlipidemia were associated with urbanisation and recent migrants (within the past four years) and long-term urban dwellers had higher risk than rural dwellers (79). However, in the present study no significant trend was evident for hypertension or diabetes. This may be explained by measurement bias, as discussed previously, which needs further exploration. The increase of overweight and obesity after migration can be explained by sudden lifestyle changes and adaptation, which is related to the consumption of abundant high-calorie fatty foods, low consumption of fruits and vegetables and a decrease in physical activity (24, 97). The association between unhealthy diet and acculturation has been documented before (98, 105). A cohort study conducted in Tanzania reported that physical activity declined significantly following migration in both genders, and saturated fat intake increased after migration (83). As diet and physical activity data was not available in this study, we could not examine their role, however, these are explored in the sibling-par comparative study (Chapter 4).

An interesting finding among rural to urban migrants was observed in the present study; cigarette smoking increased with time spent in urban living, whereas bidi smoking decreased with length of urban living. Given bidi is more prevalent in rural areas, this practice has dissolved over time among these migrants. This was an indication that acculturation happened over a period of years in the study groups. Our study findings are comparable to another study in China, where smoking levels increased among migrants as the duration of stay in urban areas increased (209). Longitudinal studies conducted in Peru (201), Tanzania (83) and Indonesia (102) also reported that smoking rate was positively associated with duration of urban stay. In the case of alcohol intake, while our results showed a significant positive trend, findings of studies in Peru (201) and Tanzania (83) reported non-significant increases in alcohol consumption.

Our results are comparable to other studies (101, 210) where the length of stay in urban areas was associated with an increased risk of migrants' psychological distress. A longitudinal study in China documented that although a mental health score increased soon after migration, it then decreased with the course of time (101). Another international migrant study also showed that mental health status deteriorated among immigrants who spent more than ten years in Spain (210). In contrast, two studies evaluating rural-to-urban migration and mental health showed the opposite relationship. A study in India reported that migrants who lived in an urban area for more than 15 years had a lower mental health disorders (209). Another study in Indonesia showed that recent migrants who lived in urban areas for less than three years were more at risk of mental health disorders and this was higher in females (102). The present study reported that the risk of mental health disorders significantly increased with time since migration only in women. The reason behind this may be the response to stress due to migration which generally manifested as depression in women (102) over time. However, social support also plays an important role in coping with stress. This could be either family support (102) or interaction with the settlers of origin at the urban destination through a strong network (207). The Indonesian study found that the detrimental effect of migration on mental health was minimal among those who moved with their family (102). In our study women who moved to urban areas for work or study were at two times higher risk of having hypertension than those who moved for familial reasons. Further sub-group analysis could reveal whether length of urban stay and mental health differ according to reasons of migration. Furthermore, the Peru migrant study (207) showed that initially migrants maintained a strong network with origin settlers but it dissolved over time due to acculturation to the urban culture and they then became isolated. As women migrant were found more vulnerable in this study, further in depth study could reveal the underlying reason.

2.5.3 CVD risk factors by place of residence

Urban populations are diverse and vary not only by economic or living conditions, but also by health status. Usually informal urban settlements, often termed ‘slums’, are the initial place of residence of rural-to-urban migrants. Thus, slum populations are increasing with rapid urbanisation in large cities of Bangladesh (164). It is estimated that more than one-third of residents in City Corporations live in slum areas. Among the City Corporations, Dhaka has the largest slum population followed by Chittagong City Corporation (166). Population size and density differs not only among City Corporations but also between slum and non- slum areas. Overall population density was higher in Dhaka (29,857 persons/km^2) and Chittagong (23,299 persons/km^2) and least in Barisal City (7152 persons/km^2), though non-slum areas are less densely populated than slum areas (166). Dhaka is emerging as one of the largest 'megacities' in developing countries and is becoming a hub of economic activities and central administration (211), which has attracted rural people to move to Dhaka. Thus, people come to Dhaka from every part of the country while the cities of Barisal and Rajshahi received migrants only from their own division (164). The pull factor of migration may differ somewhat across these cities.

Although the main focus of the 2006 UHS were the slum and non-slum areas of six City Corporations, a representative sample of District Municipalities was also drawn. The Division, a large administrative region after the Central Government of Bangladesh, is divided into two urban areas: District Municipalities and City Corporations; however, District Municipalities are a tier below the City Corporations. These three domains (slum, non-slum and District Municipality) differ greatly in terms of socioeconomic factors (e.g. household wealth quintile, education, employment, water and sanitation), exposure to media, health service availability, demographic factors (e.g. total fertility rate, contraceptive use) and health outcomes (e.g. infant mortality, neonatal mortality, stillbirth) (124, 164). Although rural-urban differences give useful information, it does not provide information about intra or inter-city differences in terms of health status. As infrastructure, demographic indicators and other amenities differed in the six City Corporations and District Municipalities, we aimed to examine if CVD risk factors differed in the sampling domain of slum and non-slum areas of different City Corporations and District Municipalities.

In this study we found a mixed pattern of risk factors among slum and non-slum dwellers. Overweight and obesity, hypertension and most diabetes cases were concentrated in non-slum dwellers whereas mental health disorders, cigarette and bidi smoking were more prevalent in slum areas and District Municipalities than in non-slum areas. The reason behind this pattern may be due to the sedentary lifestyle and unhealthy dietary practice by non-slum migrants, which could have led to a cluster of conditions known as metabolic disorders. A study conducted on middle-income neighbourhoods in Dhaka showed that the prevalence of both type-2 diabetes (35%) and metabolic syndrome (45%) was alarmingly high (212).

A limited number of studies were set up to assess the difference of chronic disease risk factors between slum and non-slum populations. A study conducted in Brazil reported that slum residents have more NCD risk factors than their non-slum dwelling urban counterparts (213). Another study in India showed that the prevalence of tobacco use is higher in slum dwellers (men 48.3%, women 11.9%) than non-slum dwellers (men 35.2%, women 3.5%) for both genders (214). It was also found that those living in slums were not aware of the adverse effect of smoking (214). The CVD risk factors studies carried out in India (215), Nairobi (216) and Bangladesh (217) showed a marked prevalence of hypertension, diabetes and obesity in urban slums. A study conducted by Khan et al. on rural-to-urban migrants in Dhaka, reported a significantly high rate of smoking and poor mental health among rural-to-urban migrants living in slums (218). Rural-to-urban migrants, in either slum settlements or non-slum areas, bear a higher risk of CVD in many regards, suggesting that different intervention strategies should be tailored for the specific CVD risk that prevails.

In comparing the City Corporations, Dhaka and Sylhet non-slum women migrants had higher metabolic risk factors (e.g., overweight and obesity, diabetes and hypertension) than other cities. For men, the proportion of metabolic risk factors was highest in Rajshahi followed by Sylhet and Dhaka. A nationwide survey in Bangladesh conducted in 2011 also showed regional variation of diabetes, where participants of the Dhaka (33.5%) and Chittagong (21.6%) Divisions had higher prevalence of diabetes than participants from Barisal (6.5%) and Sylhet (6.2%) (219). Another study also showed that the prevalence of hypertension was highest in Dhaka (33.7%) followed by Khulna (15.3%) and Rajshahi (15.3%) (220). Some of the differences across these cities can be explained by the level of environmental support for a physically active lifestyle; an established protective effect for the above conditions. Although Dhaka is a fast growing mega city, the physical environment is not favourable for physical activity due to unplanned urbanisation. Huge traffic gridlock, narrow and broken sidewalks with crowds and seasonal attributes (hot and humid in summer, rain during monsoon, dusty in winter) make dwellers unwilling to go outside for physical activity (212). Moreover, outdoor sports and recreational facilities like playgrounds, parks, swimming pools are scarce in number and 'open spaces' are inadequate (221). Currently, there are 86 parks of 193.79 acres (222) for the 14,171,567 population of Dhaka Megacity (168), i.e. less than three m^2 per person of green open space. A study conducted on Sylhet city also showed similar poor infrastructure planning (54). Although the studies of Chowdhury et al. showed a lower prevalence of diabetes and hypertension in Sylhet than other divisions, these studies

(219, 220) used Bangladesh Demographic Health Survey (BDHS) 2011 (223) data and included both rural and urban areas in the analysis.

In addition to the inconvenient infrastructure, habitual dietary practices and food consumption patterns are changing in these cities due to urbanisation. The fast food culture started in the early nineties and now it is booming in major cities as well small towns. Not only new brands e.g. Helvetia, Coopers are now established but also international brands of fast food franchises like KFC or Pizza Hut have entered into the country. A study on fast food in Dhaka showed that the consumers give most importance to brand reputation of the food item, followed by nearness to receive and accessibility (58). Urban diets are higher in fat, sugar and salt content and lower amounts of vegetables and fruits (58). A study conducted in slum areas of Dhaka city reported that insufficient fruit and vegetable intake and physical inactivity were markedly high among urban slum dwelling adults (217). Rural-to-urban migrants shifted their dietary pattern to a high sugar, salt and fat diet, which was led by urban dwellers with the increase in length of their urban stay (58). During the literature search of this thesis, we found a scarcity of studies on CVD risk factors in small cities and even in big cities. Hence, further in-depth studies are needed to focus on CVD risk factors in small cities and explore the reasons for the regional variations we found in here.

2.5.4 Strength and limitations

A large representative dataset of all urban areas in Bangladesh was considered for this study. In this study we assessed the proportion CVD risk factors, examined the association with duration of urban stay and distribution of risk factors by residence among rural-to-urban migrants, an area of inquiry which was not explored previously in Bangladesh. Further, the findings are robust given adjustment for a wide range of socio-economic factors that were assessed in the UHS.

Our study, however, was not exempt from limitations. The main limitation is the cross-sectional design that cannot examine causality. A longitudinal study design is ideal where measurements are taken before and after migration, with follow up for several years to examine how CVD risk evolves over time in relation to migration. However, such type of study is difficult in migrants because of feasibility, especially where a population registry is not available to assist with identification and tracing of migrants in the total population. Secondly, we compared the health status of migrants with urban dwellers; however, the more appropriate approach would be to compare migrants with the benchmark i.e. similar people of origin. Thirdly, in this study multiple adults were selected from each household. If any household has both migrant and non-migrant and both of them would have been selected and classified as migrant and non-migrant, this may affect their CVD risk factor profile as they probably have been sharing the same environment and diet. It may have diluted the difference of CVD risk factors between migrant and non-migrant. A further limitation is measurement bias. In this study we could not examine the smoking and alcohol behaviour among women because of a very small positive response rate to this question, which we assume was due to social desirability. Diabetes and hypertension was measured among sub-samples aged >35 years and excluded District Municipalities; thus results of this study cannot extend for younger and all urban populations, especially for small town people. Moreover, capillary blood glucose was taken for diabetes measurement, as previously discussed, which is not a diagnostic measure (unlike the OGTT). Some important behavioural (diet, physical activity) and metabolic (central obesity, dyslipidemia) risk factors data are absent in this study. We have performed an empirical study to see the effect of rural-to-urban migration on CVD risk factors where we tried to address all these limitations (Chapter 4).

2.6 Conclusion

Rural-to-urban migration is not only a demographic or economic phenomena but also bears great impact on the health status of a population. The findings of the present study highlight the distribution of CVD risk among rural-to-urban migrants, according to duration since migration and place of urban residency. This study showed that migrants had high proportion of CVD risk factors and for some adverse health issues it reached the level of lifelong urban residents. As acculturation is an obvious phenomena of migration, and in this case acculturation results in development of risk factors, strategies to change this course of events in both lifelong urban residents and rural-to-urban migrants at early stage must be developed. As one-third of the urban population lives in the slum areas and most of them are migrants, slum areas should be targeted not only for communicable diseases, as is often the case, but also for NCD public health interventions.

Chapter 3a

Validity of the Global Physical Activity Questionnaire (GPAQ) in Bangladesh

The following paper constitutes chapter 3a of the thesis and published in BMC Public Health

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3a. Validity of GPAQ

This sub-chapter is presented as a form of journal article.

Abstract

Background: Feasible and cost-effective as well as population specific instruments for monitoring physical activity (PA) levels are needed for the management and prevention of non-communicable diseases. The WHO-endorsed Global Physical Activity Questionnaire (GPAQ) has been widely used in developing countries, but the evidence base for its validity, particularly for rural populations, is still limited. The aim of the study was to validate GPAQ among rural and urban residents in Bangladesh.

Methods: A total of 162 healthy participants of both genders aged 18-60 years were recruited from Satia village (n=97) and Dhaka City (n=65). Participants were invited to take part in the study and were asked to wear an accelerometer (GT3X) for 7 days, after which they were invited to answer the GPAQ in a face to face interview.

Results: Valid accelerometer data (i.e., ≥10 hours of wear times over ≥ 3 days) were received from 155 participants (rural=94, urban=61). The mean age was 35 (SD=±9) years, 55% were females and 19% of the participants had no schooling, which was higher in the rural area (21% vs 17%). The mean±SD steps/day was 9,998±3936 (8658±2788 and 12063±4534 for rural and urban respectively, p=0.0001) and the mean±SD daily moderate-to-vigorous physical activity (MVPA) was 58±30 minutes (51±26 for rural and 69±34 for the urban, p=0.001) for accelerometer. In case of GPAQ, rural residents reported significantly higher moderate work related PA (MET-minutes/week: 600 vs. 360 p=0.02). Spearman correlation coefficients between GPAQ total MVPA MET-min/day and accelerometer MVPA min/day, counts per minute

(CPM) or steps counts/day were acceptable for urban residents (rho: 0.46, 0.55 and 0.63, respectively; $p<0.01$) but poor for rural residents. The overall correlation between the GPAQ and accelerometer for sitting was low (rho: 0.23; $p<0.001$). GPAQ-Accelerometer correlation for MVPA was higher for females (rho: 0.42), ≤35 age group (rho: 0.31) and those with higher education attainment (rho: 0.48). The Bland-Altman plots illustrated bias towards over estimation of GPAQ MVPA with increased activity levels for urban and rural residents.

Conclusion: GPAQ is an acceptable measure for physical activity surveillance in Bangladesh particularly for urban residents, women and people with high education. Given waist worn accelerometers do not capture the typical PA in rural context; further study using a physical activity diary and a combination of multiple sensors (e.g., wrist, ankle and waist worn accelerometers) to capture all movement is warranted among rural population with purposive sampling of all education levels.

Key words

Global Physical Activity Questionnaire, GPAQ, validity, physical activity questionnaire, accelerometer, Bangladesh

3a.1 Introduction

Physical activity (PA) is a key behavioural factor for maintaining health and well-being at individual and population levels (224-226). It has been estimated that at least 9% of premature mortality globally could be avoided if everyone adhered to the WHO physical activity guidelines (224). Furthermore, in 2013 the economic cost to health care systems worldwide related to non-adherence was estimated at $53 billion (227). The World Health Organization (WHO) has therefore promoted the development of PA surveillance tools in order to evaluate public health interventions and policies (228, 229) aimed at reducing the burden of non-communicable diseases (NCDs) (230).

The Global Physical Activity Questionnaire (GPAQ) is one such instrument that was endorsed by the WHO for its STEPwise Approach to Chronic Disease Risk Factor Surveillance (STEPS) (231-234). The GPAQ was developed with special consideration of key physical activity domains in developing countries and of a length and complexity suitable for inclusion in STEPS (234).

Although GPAQ has been widely used for monitoring PA, the evidence base for its validity is limited. The most extensive study to date assessing the validity of the GPAQ was conducted in 2003-2005 in nine countries including Bangladesh (235). However, since then an updated measure was released by the STEP wise program and evidence for the validity of the new version is still limited. Furthermore, six of these eight countries, including Bangladesh, used pedometers, a criterion measure which is not sensitive to activity intensity, and only four, of which Bangladesh was not one, included rural populations in their sample. The criterion validity and reliability of GPAQ for urban Bangladesh was found 0.06 and range 0.31-0.72, respectively (235).

Given there are substantial differences in patterns and frequency of PA between rural and urban populations (236-239), it is yet to be determined if GPAQ is an appropriate instrument to assess the status of PA among rural populations (235).

As a part of the surveillance system, nationwide surveys of NCD risk factors following the WHO STEPS strategy are being conducting periodically in Bangladesh. Comparison of three STEPS surveys' results (2006, 2010 & 2013) of Bangladesh clearly indicated that NCDs, particularly diabetes, are increasing (139). A comparison of the prevalence rates indicates that diabetes is becoming as problematic in rural as in urban populations (139, 240, 241). Bangladesh is facing an escalating rise of NCDs and the validity of GPAQ for the WHO STEPS in Bangladesh needs to be established for the entire population. As the Bangladeshi sample in the validation of the previous version of the GPAQ was urban, validated against pedometers and showed very poor results, this study aimed to determine the criterion validity of the new version of GPAQ in both rural and urban populations using accelerometer as the criterion measure of physical activity.

3a.2 Methodology

This study was approved by Western Sydney University Human Research Ethics committee (HREC # H11145) and Bangladesh University of Health Sciences Ethical Review Committee.

3a.2.1 Participant recruitment

A total of 162 healthy participants of both genders aged 18-60 years were recruited from rural (n=97) and urban (n=65) areas in Bangladesh. We excluded participants with chronic medical conditions that restricted their usual activity, those with mental retardation, those who were unwilling to participate and pregnant women. We calculated our sample size to detect a Spearman correlation coefficient of 0.4 (235) as statistically significantly larger than 0 assuming a $\alpha = 0.05$ significance level and 80% power to be n=55. As we will be correlating self-reported MVPA against accelerometers in each region separately the minimal required sample was 55 urban and 55 rural (110 in total).

The rural sample was selected from Satia village of Pirganj Subdistrict of Thakurgaon District. The research assistants (RA) approached the selected households (HH), introduced the study and its importance and asked permission to enroll one eligible person from each HH. If there were more than one eligible person in a HH, study participants were chosen at random using the "last-birthday method"(i.e., the person whose birthday was last or most recent) (242). Once a person was chosen and volunteered to participate, a date and time for data collection was arranged and the recruitment continued until the sample size reached.

For the urban sample, participants were recruited conveniently from faculty and staff of Bangladesh University of Health Sciences (BUHS), which is situated in Dhaka. There are 12 different employment grades from the highest grade (e.g., professor) to the lowest rank (e.g., cleaner). To ensure the validity study included all grades we used poster advertisements and emails to staff as well as actively approaching individual workers who were less likely to have access to email or more likely to be illiterate.

3a.2.2 Physical activity outcome measures

The Global Physical Activity Questionnaire (GPAQ)

Version 2 of GPAQ (235) in Bengali language was used in this study. GPAQ-2 collects information on the "usual/typical" week frequency (days) and duration (minutes/hours) of moderate and vigorous intensity PA in three domains: 1) at work; 2) during transport; and 3) at leisure (i.e., recreational activities), comprising 16 questions in total including one question on sedentary behaviour (243). We used the GPAQ scoring protocol (243) to create the following indicators: total MVPA MET-min and domain specific MVPA MET-min (i.e., work, transport, recreation).

METs (Metabolic Equivalent Tasks) are commonly used to express the intensity of PA. When calculating a person's overall energy expenditure using GPAQ-2, moderate-intensity activities during work, commuting and recreation are assigned a value of 4 METs; vigorous-intensity activities are assigned a value of 8 METs. The total MVPA MET-min score is computed as the sum of all MET-min/week from MVPA performed in work, commuting and recreation.

Accelerometer

To investigate the criterion validity we chose the Actigraph GT3X accelerometers as objective sensor-based activity monitors to provide the criterion measure. Accelerometers are considered as more accurate than self-report for measuring time spent in different intensities and therefore used as criterion in validation of subjective self-report questionnaires (244). The GT3X accelerometer is small, noninvasive and contains a 3-axis microelectromechanical system which measures the quantity and intensity of movement (http://actigraphcorp.com/).

Participants wore the accelerometer for seven consecutive days, except during sleep and water based activities. The device was worn at waist level above the hip of the left side. The data were stored in 10-sec intervals and aggregated into 1-min epochs, a procedure recommended for accelerometer studies in adults (245). Actigraph Actilife software was used for initialization and analyses of accelerometer data. For validity analysis, at least 10 hours/day of recording were considered as a valid representative day and at least three valid days, including one weekend day, of data to represent weekly habits (245). We compared the CV of the accelerometer MV time per week for a sample of 3 days (n=155) to a sample of 4 days (n=146) and we found no change in the CV (0.53 vs. 0.52). Hence for the sake of keeping the large sample we chose the lowest number of days. Atkin et al. (246) and Freedson et al. (247) cut points were taken to classify time spent in sedentary (<100 counts/min), light (<1952 counts/min), moderate (1952-5724 counts/min), and vigorous (>5724counts/min) physical activities using vertical axis.

3a.2.3 Data collection

Six trained research assistants with a minimum of university graduation were recruited for data collection. All field research assistants were trained in conducting face to face interviews, including the GPAQ, and in measurements, including accelerometer data collection. Training sessions were properly guided by the facilitators and supervisors. On the first meeting day, study procedures were explained and informed consent obtained. Each participant was then fitted with an accelerometer and shown how to remove and re-wear the device. Basic socio-economic information was taken by interview on that day. A second meeting with the same interviewer was scheduled 7 days later at which the GPAQ interview was undertaken and the accelerometer collected for data downloading.

3a.2.4 Data analysis

After data entry, range and consistency were checked. For the general description of data, frequency analyses were calculated as number (percentage), mean (±SD) or median (IQR) when appropriate. Spearman's correlation coefficients were used for comparison of total GPAQ MVPA MET-minutes/day, domain specific MET-minutes/day and sedentary behaviour minutes/day with accelerometer derived average minutes spent in MVPA, counts per minute, steps per day and sedentary behaviour minutes/day. Further Cohen's Kappa statistic was used to examine the agreement of GPAQ and accelerometer in categorizing whether or not individuals meet the physical activity guidelines of at least 150 minutes of MVPA per week. The magnitude of bias was tested by the Bland-Altman method comparing the mean differences between MVPA MET-minutes per day from the GPAQ all domains & sedentary behaviour and accelerometers for urban and rural populations. We have presented correlations for total sample and by subgroup. Main stratification was done by place, but further stratified by gender, age and education. To interpret agreement we used following standards: 0-0.20 = poor; 0.21-0.40 = fair; 0.41-0.60 = moderate/acceptable; 0.61-0.80 = substantial; 0.81-1.0 = near perfect (235, 248). All p values presented were two tailed. The statistical tests were considered significant at a level of 5 % (0.05). Data was analyzed using SPSS (version23) statistical software.

3a.3 Results

The characteristics of the 162 study participants are described in Table 3a.1. Fifty-five percent were female, the overall mean age was 35 (SD=±9) years and 19% of the participants had no schooling, which was higher in the rural compared to the urban population (21% vs 17%). There were no significant differences in the age by gender distribution. Valid accelerometer data (i.e., ≥10 hours of wear times over ≥ 3 days) were received from 155 participants (urban=61, rural=94). The mean±SD steps/day was 9,998±3936 (8658±2788 and 12063±4534 for rural and urban respectively, p=0.0001) and the mean daily MVPA was 58 minutes (51 for rural and 69 for the urban, p=0.001). Based on GPAQ, rural residents reported significantly higher moderate work related PA (median MET-minutes/week: 600 vs. 360 p=0.02) than did urban residents.

Table 3a. 1: Characteristics of the study subjects according to rural and urban

Variables	Total (n=162)	Rural (n=97)	Urban (n=65)	
	n (%)	n (%)	n (%)	*p*[1]
Age				
≤30 years	56 (34)	29 (30)	28 (43)	0.002
31-40 years	66 (41)	38 (39)	32 (49)	
≥41years	40 (25)	30 (31)	5 (8)	
Gender				
Male	74 (46)	47 (49)	27 (41)	0.42
Female	88 (54)	50 (52)	38 (59)	
Marital status				
Unmarried	23 (14)	12 (12)	11 (17)	0.52
Married	138 (85)	84 (87)	54 (83)	
Others	1 (1)	1 (1)	0 (0)	
Education				
Illiterate	18(11)	10 (10)	8 (14)	0.0001
Informal education	13 (8)	11 (11)	2 (3)	
Primary school completed	40 (25)	31 (32)	9 (13)	
High school completed	62 (38)	39 (41)	23 (35)	
University level	29 (18)	6 (6)	23 (35)	
	Median (Q1; Q3)	**Median (Q1; Q3)**	**Median (Q1; Q3)**	*P*[1]
GPAQ (MET-mins/wk)	**(n=155)**	**(n=94)**	**(n=61)**	
Work				
Vigorous	0 (0; 1120)	0 (0; 1200)	0 (0; 700)	0.76
Moderate	480 (240; 1200)	600 (240;1250)	360 (42; 1020)	0.02
Total Work MVPA	840 (280; 2280)	1000 (360; 2280)	600 (130; 2390)	0.14
Travel				
Moderate	840 (480; 1680)	1060 (560;1680)	840 (420; 1680)	0.07
Recreation				
Vigorous	0 (0; 0)	0 (0; 0)	0 (0; 0)	0.94
Moderate	480 (240; 1120)	480 (270; 1140)	480 (60;1400)	0.33
Total Recreation MVPA	600 (240; 1440)	700 (300;1440)	560 (120;1680)	0.32
GPAQ Total MVPA	3320 (1680; 5760)	3440 (2270; 5880)	3220 (1180; 5710)	0.23
Sedentary mins/day	120 (60; 180)	120 (90; 180)	120 (60; 180)	0.12
	Mean (SD) / Median (Q1; Q3)	**Mean (SD)/ Median (Q1; Q3)**	**Mean (SD)/ Median (Q1; Q3)**	*P*[2]
Accelerometer	**(n=155)**	**(n=94)**	**(n=61)**	
Valid Days	6.09 (1.38) 6 (5; 7)	5.90 (1.42) 6 (5;7)	6.38 (1.28) 6 (6; 7)	0.037
CPM (Axis 1)/ day	67.42 (25.10) 64.80 (47.40; 84.90)	63.12 (21.45) 60.35 (46.95; 76.25)	74.06 (28.80) 75.20 (52.25; 93.05)	0.01
Steps/day	9998 (3936) 9082 (6969; 12474)	8658 (2788) 8407 (6745; 10507)	12063 (4534) 12353 (8509; 14531)	0.0001
MVPA mins/day	57.96 (30.39) 50.95 (36.07; 76.00)	51.10 (25.57) 46.08 (32.87; 64.99)	68.57 (34.21) 62.03 (43.29; 92.29)	0.001
Light mins/day	211.69 (67.38) 209.30 (157.64; 253.10)	205.76 (59.09) 210.46 (150.48; 245.39)	220.83 (78.12) 207.52(158.54; 275.86)	0.20
Sedentary mins/day	551.15 (83.03) 546.03 (494.73; 607.05)	554.26 (81.43) 546.98 (497.06; 609.76)	546.35 (85.90) 546.03 (480.31; 606.12)	0.56

Results are expressed as number (%), mean (SD) and median (Q1:Q3); ns=not significant, [1]Mann-Whitney U test; [2]t-test

Table 3a.2 shows the correlation between physical activity assessed by the GPAQ and measured by the accelerometer. Spearman correlation coefficients between GPAQ total MVPA and accelerometer MVPA, CPM or steps counts were low for the whole population (rho: 0.18, 0.24, and 0.28, respectively). However, stratification by place of residency indicated good correlations for urban residents (rho: 0.46, 0.55 and 0.63, respectively; $p<0.01$) and very poor correlations for rural residents (rho: 0.0001, -0.01 and 0.05, respectively). The domain specific correlations across all indicators (i.e., MVPA, CPM or steps counts) among urban population were high for the work, travel and leisure domains (0.26 to 0.55) but among rural residents the coefficients were low for all domains. GPAQ occupational and leisure related PA showed significant fair to moderate correlation with light-intensity PA for urban population. Time in light intensity was inversely related to travel-related activity in rural area. A significant, low level of agreement between the GPAQ and accelerometer data for sitting was observed (rho: 0.23; $p<0.01$). The agreement for categorization of participants into meeting sufficient physical activity level was fair for all participants (Kappa: 0.29; $p<0.0001$) and good for urban participants (Kappa: 0.62; $p<0.0001$) though low for rural participants (Kappa: 0.07) (data not shown).

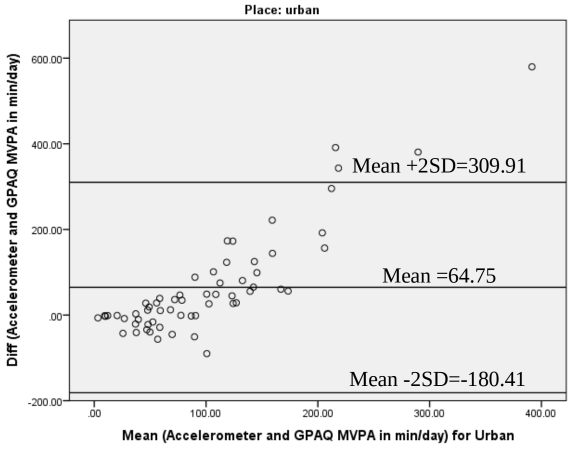
Table 3a. 2: Spearman correlation coefficients for all GPAQ and domain specific MVPA against accelerometer indicators

Accelerometer Indicators		GPAQ				
		Total MVPA MET-mins/day	**Work-related activities MET-mins/day**	**Travel-related activity MET-mins/day**	**Leisure-time activities MET-mins/day**	**Sitting**
All	Steps/day	0.28**	0.25**	0.08	0.11	-0.14
	MVPA (mins/day)	0.18*	0.13	0.03	0.12	-0.10
	CPM (Axis 1)	0.24**	0.23**	0.02	0.11	-0.18*
	Light (mins/day)	0.17*	0.29**	-0.07	0.003	-0.21*
	Sitting (mins/day)	-0.23**	-0.21*	-0.08	-0.11	0.23**
Urban	Steps/day	0.63**	0.55**	0.52**	0.41**	-0.03
	MVPA mins/day	0.46**	0.38**	0.49**	0.26*	0.04
	CPM (Axis 1)	0.55**	0.50**	0.46**	0.29*	0.02
	Light (mins/day)	0.57**	0.58**	0.29*	0.27*	-0.10
	Sitting (mins/day)	-0.42**	-0.43**	-0.24	-0.28*	0.07
Rural	Steps/day	0.05	0.07	-0.13	-0.12	-0.17
	MVPA mins/day	0.0001	-0.03	-0.20*	0.02	-0.17
	CPM (Axis 1)	-0.01	0.02	-0.23*	-0.05	-0.33**
	Light (mins/day)	-0.2	0.05	-0.30**	-0.20	-0.27**
	Sitting (mins/day)	-0.10	-0.05	-0.001	0.02	0.38**

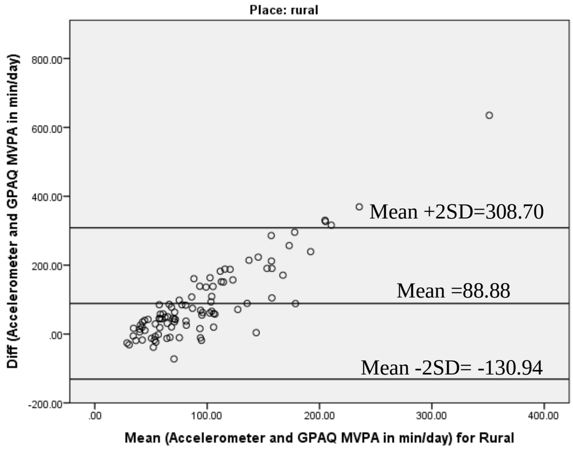
**Statistically significantly different from 0 at p< 0.05 ** Statistically significantly different from 0 at p<0.01*

Figures 3a.1a and 3a.1b present the Bland and Altman plots for the agreement between GPAQ MVPA min/day for all domains and accelerometer MVPA in min/day by place. Figure 3a.1a & 3a.1b showed that the differences between the two instruments were 64.75 and 88.88 minutes of MVPA per day, respectively. The limits of agreement were wide with the difference lying between -180.41 to 309.91 min/day for urban and -130.94 to 308.70 for rural. A clear pattern of increased error was detected with increased average of PA. Figures 3a.1c & 3a.1d showed the difference between the two instruments in urban and rural participants were -419.63 and -415 minutes of SB per day with wide difference (-612 to -220 min/day and -577.02 to -252.98 min/day) which indicates negative bias exists for the GPAQ.

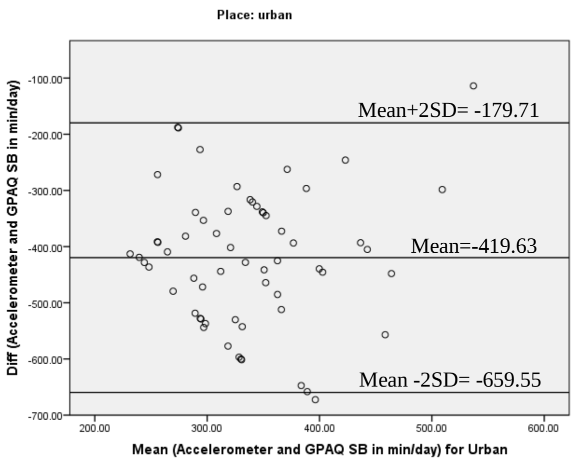
a.


Place: urban
Mean +2SD=309.91
Mean =64.75
Mean -2SD=-180.41
Diff (Accelerometer and GPAQ MVPA in min/day)
Mean (Accelerometer and GPAQ MVPA in min/day) for Urban

b.


Place: rural
Mean +2SD=308.70
Mean =88.88
Mean -2SD= -130.94
Diff (Accelerometer and GPAQ MVPA in min/day)
Mean (Accelerometer and GPAQ MVPA in min/day) for Rural

c.


Place: urban
Mean+2SD= -179.71
Mean=-419.63
Mean -2SD= -659.55
Diff (Accelerometer and GPAQ SB in min/day)
Mean (Accelerometer and GPAQ SB in min/day) for Urban

d.

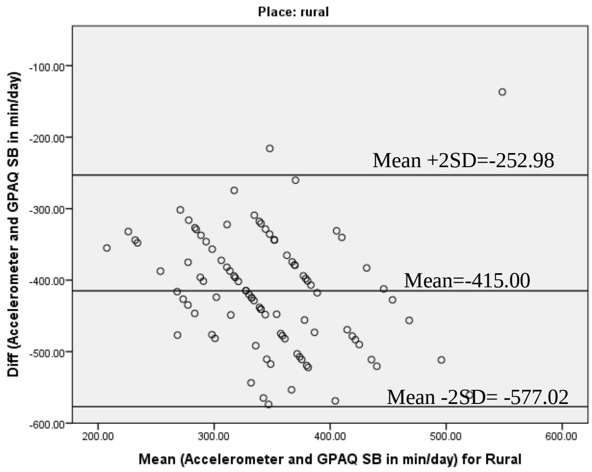


Figure 3a. 1: Bland-Altman plots showing the agreement between GPAQ and Accelerometer. a. Agreement of MVPA for urban (n=61) b. Agreement of MVPA for rural (n=94) c. Agreement of sedentary behaviour for urban (n=61) d. Agreement of sedentary behaviour for rural (n=94)

Table 3a.3 shows the correlation between GPAQ total MVPA MET-mins/day and accelerometer MVPA, CPM and steps across sociodemographic subgroups. Consistent, significant correlations were found between GPAQ total MVPA and accelerometer MVPA, CPM and steps among women (rho: 0.42, 0.46 & 0.49 respectively) and young adults (age ≤35 years) (rho: 0.31, 0.32 & 0.34 respectively). After stratification by place, significant fair-to-moderate correlation was found for females, whereas urban young adults showed a significantly higher correlation than young rural adults. For education subgroups, the patterns of the correlations were inconsistent and did not follow gradient. Overall the correlations with GPAQ MVPA and accelerometer MVPA, CPM and steps were moderate for the graduate group (rho: 0.48, 0.45 & 0.51 respectively) and fair for the illiterate (rho: 0.27, 0.34 & 0.51 respectively) and primary group (rho: 0.23, 0.20 & 0.38 respectively).

Table 3a. 3: Spearman Correlation Coefficient between GPAQ MVPA MET-mins/day and accelerometer measures in subgroups

Sub groups		Steps/day	MVPA (mins/day)	CPM (Axis 1)
Gender				
All	**Male** (n= 70)	0.05	-0.10	0.04
	Female (n= 85)	0.49**	0.42**	0.46**
Urban	**Male** (n= 26)	0.56**	0.61**	0.53**
	Female (n= 35)	0.67**	0.55**	0.65**
Rural	**Male** (n= 44)	0.15	0.01	0.22
	Female (n= 50)	0.21	0.29*	0.30*
Age, years				
All	**≤35** (n= 93)	0.34**	0.31**	0.32**
	> **35** (n= 62)	0.19	-0.03	0.10
Urban	**≤35** (n= 49)	0.59**	0.48**	0.52**
	> **35** (n= 12)	0.73**	0.50	0.71**
Rural	**≤35** (n= 44)	0.12	0.19	0.11
	> **35** (n= 50)	0	-0.18	-0.11
Education				
All	**Illiterate** (n= 30)	0.22	0.27	0.35
	Primary school level (n= 37)	0.38*	0.23	0.20
	High school level (n= 61)	0.05	-0.01	0.01
	University level (n=27)	0.51*	0.48*	0.45*
Urban	**Illiterate** (n= 9)	0.30	0.12	0.53
	Primary school level (n= 7)	0.32	0.10	0
	High school level (n= 23)	0.31	0.22	0.20
	University level (n= 22)	0.68**	0.76**	0.67**
Rural	**Illiterate** (n= 21)	0.15	0.38	0.32
	Primary school level (n= 30)	0.34	0.20	0.16
	High school level (n= 38)	-0.28	-0.30	-0.24
	University level (n= 5)	0.50	0.80	0.87

**Statistically significantly different from 0 at p< 0.05 ** Statistically significantly different from 0 at p<0.01*

3a.4 Discussion

To the best of our knowledge this is the first validity study of the GPAQ in Bangladesh using accelerometer and also including rural population. The results demonstrated moderate evidence of criterion related validity for total GPAQ MVPA and all domains of MVPA for urban participants but poor criterion validity for rural participants. The GPAQ demonstrated fair-to-moderate criterion validity for women, young adults (≤35 years) and those with higher level of education.

Our results contradict some findings from the nine countries validity study by Bull et al (235). First, the rural samples (Ethiopia, Indonesia and India) had better coefficients (rho: 0.43) than their counterpart urban sample (rho: 0.23), albeit the criterion was pedometer steps counts. Second, in the nine countries' samples the validity coefficients were better for men than women whereas in the current study it was the other way around. Third, China and South Africa used accelerometers as the criterion measure for urban samples and the coefficient between GPAQ total PA across all domains and accelerometer moderate-intensity counts per minute were 0.24 for China sample and very poor (-0.01) for South Africa sample, much lower than the coefficient for counts per minutes in our urban sample. In the nine countries study, criterion validity for urban Bangladesh was assessed by pedometer, which is a less sensitive objective measure than the accelerometer used in the current study. The overall correlation was 0.06, which was considerably lower than in our current study where accelerometer was used (235).

Our results are comparable to other studies where low-to-moderate validity (rho: 0.20-0.48) was demonstrated against objective measures (229, 249-255). Additionally, in the 12 countries study validation of the short International Physical Activity

Questionnaire (IPAQ), the pooled validity correlations against accelerometers was found to be 0.30 (95% CI 0.23-0.36) (256). In the Bland-Altman plot a clear pattern of increased error was detected with increased average of PA for rural and urban participants. Overestimation of GPAQ was observed in the US (249) and Singapore (250), whereas negative bias was seen in the Northern Ireland with the majority of points falling below zero (229).

Several reasons may explain the low validity of GPAQ for our rural population as opposed to the urban sample; firstly, the dominant work-related PA in rural area is farming, it is a hard work that involves digging, cutting crops, rice processing, carrying heavy loads etc. but the positioning of waist-worn accelerometers affects their ability to capture these upper body movement activities. Further, non-ambulatory activities such as cycling is also not captured by waist-worn accelerometers, and cycling is a very prevalent mode of transport in rural areas (257, 258), particularly among men. Additional explanation may be related to the pace of ambulation in the country-side which may result in accelerometer counts below the cut-off point for moderate activity (247). For example, the Freedson determination of moderate and vigorous PA accelerometer cut points were based on walking and running on a treadmill (247) and are unlikely to capture the intensity associated with walking carrying heavy loads or on uneven surface as is common in rural areas of developing countries such as Bangladesh and thus accelerometer may underestimate total MVPA in these populations (259). Support for this argument is the good correlation we found with time spent on light-intensity PA based on accelerometer and GPAQ occupation and travel-related physical activity, a correlation that was in the same range as for accelerometer MVPA. This may indicate that lowering the cut-point may improve the indicators for GPAQ validity.

Moreover, reference time of the GPAQ is 'usual week' which may create confusion in the participants to determine which particular week of a month would be best to address. The 12-countries study of validation on IPAQ discussed that the understanding of a 'usual week' was difficult for participants as they were not able to identify 'what is usual?' and participants recalled last 7 days instead of 'usual week' (256). This could be more problematic if there is strong seasonal variation. In Bangladesh, there are 6 seasons and the main occupation in rural area is agriculture which follows the seasons (260). A multi-site study of nine Asian rural areas including Bangladesh showed that PA was lower in the middle of the harvest season and increased during the more intensive harvest period (261). Another reason for the low correlation of GPAQ MVPA in rural participants might be that accelerometer data were collected in autumn season when people are less active and GPAQ MVPA was the usual week. On the other hand, urban residents had almost similar work patterns throughout the year because our urban participants were selected from one work site where occupation related PA is stable throughout the year.

In the subgroup analysis, females showed consistent correlations across all indicators of PA. In male overall correlation across indicators of PA was not seen, whereas other studies showed reverse result (229, 262, 263). This may be due to the context specific nature of activities undertaken within both urban, and, particularly, rural Bangladesh which often requires considerable upper-body motion such as labor-intensive farming practices, as noted before, or construction jobs in the city. Moreover, males carry heavy loads such as crops, seeds, sacks etc. which limits their pace of walking. Both pedometers and accelerometers are likely to underestimate the intensity of these activities despite their being moderate-intensity efforts subjectively, as well as by energy expenditure measure (Ainsworth range 5METs to 8.5METS) (264). In addition, swimming and cycling are common activities for rural people. Because accelerometers do not measure water-based and non-ambulatory activities, this may have contributed to the poor correlations found in males. In case of education, the patterns of the correlations were inconsistent and did not follow gradient, however, higher correlation was found in tertiary education group than other groups. This finding is similar to that of a study by Lee et al. who found that participants who had tertiary education performed better for IPAQ and over-reporting was almost double in those without tertiary education (262). The nine countries study of GPAQ validation also showed higher correlation for those with higher education compared with those with less than 13 years of schooling (235), as in our study. Therefore it is possible that the overall low validity in rural sample was confounded by the lack of representation of participants with graduate degree in this sample. Yet, the coefficients for the illiterate groups, in both places, were better than those with primary and high-school education. The lack of gradient in coefficients by education levels suggest that factors other than cognitive errors may have contributed to the low validity such as the type of occupation they do (static, non-ambulatory).

The current study found the volume of sedentary behaviour (SB) was greater when measured by the accelerometer than by the GPAQ. This finding is similar to that of recent study where found that when SB was measured with a self-reported single item it significantly underestimates SB in comparison to accelerometer data (265). However, a study conducted on a Chilean population found the single question from the GPAQ had fair validity for measuring SB, though poor ability for correctly classifying individuals into tertiles or quartiles of SB (252). Our finding of a low correlation (rho: 0.23) between GPAQ measurement for minutes of sitting per day and accelerometer data agrees with previous studies (229, 235), nevertheless, this correlation coefficient increased for rural (rho: 0.38). Present findings demonstrate that GPAQ may not be appropriate when assessing minutes of SB for both urban and rural populations as it results with systematic under-estimation of amount of sitting by 7 hours on average (range between 3 to 11 hours) compared to accelerometer and this was true for both rural and urban population. More accurate measurement of SB may be provided by using a multiple item domain-specific questionnaire (265, 266).

The study had a number of strengths as it assessed validity of GPAQ-2 both in urban and rural population which is rare in Bangladesh and in general. Secondly, there was good compliance with accelerometer wear and adherence to the study protocol. Additionally, we followed WHO guidelines for administering the GPAQ, provided intensive training on data collection staff and close supervision during data collection to minimize avoidable sources of measurement error.

We used a triaxial Actigraph accelerometer as a reference measure for criterion validity. The gold standard measurement for assessing energy expenditure are indirect calorimetry, doubly labelled water or heart rate monitoring, however, these are expensive and require technical expertise for implementation. Accelerometers are a widely used alternative for objective measurement as they are relatively less expensive, feasible, have been validated against DLW and showed a good level of reliability (229, 267). Nevertheless, accelerometers have their limitations. For example, in this study accelerometer data likely underestimated MVPA in the rural sample due to its inability to capture water-based, non-ambulatory and statics activities. Thus, using accelerometer as a criterion might be considered as concurrent or convergent instrument due to its pitfalls.

On the other hand, over-reporting with activity questionnaires is ubiquitous as they are prone to biases such as recall and social desirability (268, 269). So, these could lead to overestimation of activity levels in some domains and underestimation in others. It could be better explained if we know the pattern of activities of rural Bangladesh where PA varies with seasonality. Moreover, GPAQ does not capture details of many activities culturally relevant to Bangladesh. These might be the reasons that low PA was found to be almost similar in both urban and rural (28.9 & 25.1 respectively) population in 2010 Bangladesh NCD Risk Factor Survey where GPAQ was used (188). Hence, we suggest that in the introduction of the questionnaire the typical week should be referenced to the typical week of the season or asking about the past week, as is the case in many surveillance questionnaires. Another limitation could be that the urban sample was comprised of volunteers from a workplace setting, thus the results may not have complete reflection of the general urban population.

3a.5 Conclusion

In conclusion, the present study adds important new data on the validity of the widely-used GPAQ for estimating PA and SB levels in a low income country. For the whole population, the GPAQ performed as well as other population PA surveillance tools. Its performance with regard to the urban population was at the highest range of most surveillance tools and better than for the rural population. The GPAQ seems to be an effective tool for measuring PA in females and people with high levels of education.

Given waist worn accelerometers do not capture the typical PA in rural context; further study using a physical activity diary and a combination of multiple sensors (e.g., wrist, ankle and waist worn accelerometer) to capture all movement would be informative. Such a study should include purposive sampling of all education levels to ascertain the extent to which education level is associated with better performance.

Chapter 3b

Seasonal variations in physical activity domains among rural and urban Bangladeshi using a culturally relevant Past-Year Physical Activity Questionnaire (PYPAQ)

The following paper constitutes chapter 3b of the thesis and under review in Journal of Environmental and Public Health

Mumu SJ, Fahey P, Ali L, Rahman AKMF, Merom D. Seasonal variations in physical activity domains among rural and urban Bangladeshi using a culturally relevant Past-Year Physical Activity Questionnaire (PYPAQ). Journal of Environmental and Public Health. In press.

3b. Seasonality and Validity of PYPAQ

This sub-chapter is presented as a form of journal article. The seasonal variation of physical activity using PYPAQ was described here and the table of PYPAQ validity is given at the Annexure 3b.1.

Abstract

While the effect of weather and seasons on physical activity (PA) is well documented for leisure-time physical activities in western countries, scant information is available for developing countries where lifestyle PA is the major source of energy expenditure (EE). In Bangladesh the traditional calendar divides the year to six seasons of lasts two months each: summer; rainy; autumn; late autumn; winter and spring. We developed the Past Year Physical Activity Questionnaire to record culturally-relevant physical activities and to help assess the seasonal variation in total and domain-specific PA in Bangladesh. We have applied this tool to men and women aged 18-60 years residing in Dhaka city and in the northern rural district of Thakurgaon. An age- and gender-adjusted model revealed significantly lower levels of EE in urban residents compared to rural residents across all seasons and domains. We also found evidence of seasonal variations in moderate-to-vigorous physical activity (MVPA) MET-min/week among rural participants for total (range 3192 in autumn to 4124 in winter; p=0.0001) and only in the occupational (range 935 in autumn to 1645 in winter; p=0.0001) gardening (range 2.46 in late autumn to 29.28 in rainy season; p=0.0001) and leisure time (range 229 in late autumn to 272 in rainy season; p=0.005) domains. There were no seasonal differences of total and domain specific MVPA in urban except household related PA. Among rural participants PA was higher in the summer, rainy and winter seasons and lower in autumn and late autumn. The most common leisure-time physical activities were walking, bicycling and swimming with higher participation in the rural area. Leisure-time physical activity needs to be promoted to urban residents all year long but more focused on autumn, late autumn and spring in rural areas.

Keywords: Seasonality; Past Year Physical activity Questionnaire (PYPAQ); Leisure-time; transport; Occupation; energy expenditure; Rural; Urban; Bangladesh

3b.1 Introduction

In recent years there has been increasing recognition of the role of physical activity (PA) in primary and secondary prevention of non-communicable diseases (NCDs). This has occurred in both high- and low-income countries (226, 270, 271). It has been estimated that at least 9% of premature mortality globally could be avoided if everyone adhered to the PA guidelines of World Health Organization (WHO) (224). Hence, monitoring and promoting PA is a public health priority.

The role of the man-made environment in shaping PA patterns has been extensively studied in the past two decades; particularly in relation to urban design. However, the impact of season, weather, geography and culture on PA is less well known (272). A review of the international literature on PA seasonality and regional variations by Tucker et al highlighted that weather is a barrier for PA participation and that both adults and children are generally more active in the summer than during the winter (272). This review relied on data from eight different studies all, with the exception of one study of Guatemalan children, were conducted in developed countries (USA, Canada, UK, France, Netherlands and Australia). Hence, the accumulated knowledge of seasonal variations in PA mostly pertains to leisure-time physical activity (LTPA); a domain that contributes significantly to total PA in the western world (273, 274). Little is known about seasonal variations in PA in developing countries, such as Bangladesh, where lifestyle PA is the major contributor to overall PA. The studies which have been conducted in Bangladesh have shown that less than 15% of the population participate in any moderate-to-vigorous LTPA and that occupation and travel were the major contributors to total PA in both urban and rural areas (270, 271). The impact of season is not yet documented.

Traditionally, Bangladeshis' subdivide the year into six seasons which follow the agricultural cycle. Each season lasts two months. The year begins with summer (from mid-April to mid-June), followed by the rainy season (mid-June to mid-August), autumn (mid-August to mid-October), late autumn (mid-October to mid-December), winter (mid-December to mid-February) and spring (mid-February to mid-April) (275). However, in terms of weather conditions, three main seasons are distinguishable: a hot, humid summer or pre-monsoon from March to June; a cool, rainy monsoon season from June to October; and a cool, dry winter from October to March. Further, given the more traditional rural lifestyle and the more westernized urban lifestyle, the impact of seasons on PA may differ between rural and urban residents. This makes Bangladesh an interesting place to explore seasonality. In order to better measure the PA pattern in Bangladesh and to inform future intervention strategies, we have developed the Past Year Physical Activity Questionnaire (PYPAQ) which assesses culturally relevant moderate-to-vigorous physical activities (MVPA) categorized into key domains and incorporating each season. The aims of this study were to: 1) test for seasonal variation in total energy expenditure and in each PA domain; 2) compare seasonal variation in average PA between a group of rural residents and a group of urban residents.

3b.2 Methods

3b.2.1 Participants and data collection

Ethics approval was obtained from the Western Sydney University Human Research Ethics Committee (HREC # H11145) and the Bangladesh University of Health Science Ethical Review Committee.

Participants in this study were recruited for a validation study which is fully described elsewhere (276). Briefly, a group of rural residents were selected from Satia village of Pirganj Subdistrict of Thakurgaon District and a group of urban residents from the Bangladesh University of Health Sciences (BUHS), which is situated in the north of Dhaka city. Urban participants were recruited conveniently from twelve distinct occupations ranging from professor to cleaner. For the rural sample, each household (HH) of Satia village was approached starting at the nearest house on the left side of the main road, then moving on to the next-nearest HH until the sample size was reached. The inclusion criteria for both places were that participants had to be of either gender, aged between 18 and 60 years and generally healthy. We excluded those who were physically disabled or suffering from any chronic medical condition which limited their physical activity; including mental retardation. We have asked the potential participants or their relatives about any medical condition that they had. If they had any medical records, we checked those for confirmation. We excluded pregnant women as this may also affect pattern of PA.

3b.2.2 Past year physical activity questionnaire (PYPAQ) development

We used the Minnesota Leisure Time Physical Activity (MLTPA) Questionnaire (277) as a template for this questionnaire. In particular, we followed its recall time frame that allows the recording of seasonal changes in PA. In the MLTPA Questionnaire the respondent is asked to report the frequency and amount of time spent on each PA over the previous year on a month-by-month basis. The list of types of PA people could participate in is extensive and each is assigned a PA intensity code or Metabolic Equivalent Tasks (METs). The PA intensity codes were derived from the Physical Activity Compendium. (277, 278)

We have changed the list of activities to match the Bangladesh culture. The activities are grouped into five domains: occupation; transport; household; gardening; and leisure-time activities. Within the occupation category there are six subcategories: farming; driving; day laboring; tailoring; office work (i.e., doctor, teacher, executive etc.) and "other". The questionnaire assesses PA over the previous year covering all six seasons (275). Trained interviewers asked respondents for detail about their physical activities during the past 12 months and recorded comprehensive information on each activity undertaken. For example, participants were asked to specify the months in which the activity was performed, the usual frequency per month and the number of hours spent per occasion. The questionnaire captures all PA including paid employment and gathers detailed information on time spent sitting, standing and walking while at work.

3b.2.3 PYPAQ outcome measures

Using the Compendium of PA we first assigned the appropriate MET value to each activity reported (264). A MET is the ratio between the energy expenditure while performing the activity relative to energy expenditure when in a resting position (1 MET). We considered METs from 3.0 to 6.0 as moderate activity and greater than 6.0 as vigorous activity. For example, the intensity code of brisk walking is 3.8 METs, which suggests that this activity is a moderate-intensity activity and has 3.8 times higher energy expenditure than resting on average.

The MET-hours per year for each activity for each respondent was calculated the MET for that activity multiplied by the number of months when the activity was performed multiplied by the average number of occasions per month that the activity was performed, multiplied by average duration per occasion. Each participant's domain specific PAs were obtained by summing the MET-hours per year of all activities listed in that domain (e.g. occupation, transport, household etc.). Finally, results were converted to MVPA MET-hours per week (by dividing by 52) and MVPA MET-minutes per week for analysis and presentation.

We validated PYAPQ against the Global Physical Activity Questionnaire (GPAQ) and concurrent validity for total MVPA was 0.42. Spearman's correlation between the GPAQ measure of usual week MVPA and the PYPAQ average weekly MVPA was 0.61 and 0.39 for urban and rural residents, respectively. We also investigated construct validity by a range of physiological indicators of PA such as anthropometry, physical fitness and biochemical measures and total MVPA showed significant inverse association with weight (ρ= -0.2) and waist circumference (ρ= -0.3). (Annexure 3b.1)

3b.2.4 Statistical analysis

The sample size was determined by the needs of a previous analysis. However, if designing a new study of this type, the current sample size would allow at least 80% power to detect a 0.30 or more standard deviation decrease in mean MVPA in two seasons (relative to the other four) as statistically significant in the rural group assuming a conservative 0.2 correlation in MVPA between seasons. An equivalent 0.38 or more standard deviation change in the urban group would have at least 80% power of being detected as statistically significant and a 0.45 or more standard deviation change in the rural group would have at least 80% power to be detected as statistically significant. GLIMMPSE (https://glimmpse.samplesizeshop.org) was used for these calculations.

After data entry, data were checked and cleaned using range and consistency checks. The demographic characteristics of the samples are presented as frequency counts and associated percentages for categorical measures and mean (±SD). The distributions of continuous measures were visually reviewed with the aid of histograms. Distributions were summarized using means and standard deviations if symmetric or with medians and 25th and 75th percentiles if non-symmetric. Pearson's Chi-square test and the independent samples t-test were used to test for evidence of differences between the rural and urban populations on sociodemographic and health outcome variables respectively. Repeated Measures Analysis of Variance (RMANOVA) was used to test for evidence of variation in PA between place and seasons. Because the activity data were positively skewed, the square root transformation was used to produce data for analysis which followed a normal distribution. Results were back transformed before reporting in the Tables. Within the RMANOVA the Greenhouse-Geisser test was used to so as to avoid the assumption of sphericity. Subgroup analyses were used to investigate the seasonal variation in PA within the rural and urban groups separately. All p values below the α=0.05 significance level was considered statistically significant evidence of difference between groups or within groups across seasons. Data was analyzed using SPSS (version 23) statistical software.

3b.3 Results

Participants characteristics

The characteristics of the 162 study participants, rural (n=97) and urban (n=65) are described in Table 3b.1. Fifty-five percent were female, the overall mean age was 35 (SD=±9) years and 19% of the participants had no schooling, two thirds of participants owned a house and 82% owned their land. Significant regional differences were noted by age, education, household and land ownership. Urban residents were younger than rural residents (43% vs 34%) and had a higher proportion of people who completed high-school or university degree than the rural residents (70% vs 47%). As expected, ownership of house and land was much higher for rural residence than urban residence.

Table 3b. 1: Characteristics of the study subjects according to rural and urban

Variables		**Total (n=162)**	**Rural (n=97)**	**Urban (n=65)**	
		n (%)	**n (%)**	**n (%)**	***p***
Age					
	≤30 years	56 (34)	28 (29)	28 (43)	
	31-40 years	66 (41)	35 (36)	31 (48)	0.001
	≥41years	40 (25)	34 (35)	6 (9)	
Gender					
	Male	74 (45)	47 (49)	27 (41)	0.42
	Female	89 (55)	50 (52)	39 (59)	
Marital status					
	Unmarried	17 (10)	10 (10)	11 (17)	
	Married	131 (81)	86 (89)	55 (83)	0.52
	Others	15 (9)	1 (1)	0 (0)	
Education					
	Illiterate	17 (10)	8 (8)	9 (14)	
	Informal education	15 (9)	13 (13)	2 (3)	
	Primary school completed	40 (25)	31 (32)	9 (13)	0.0001
	High school completed	62 (38)	39 (41)	23 (35)	
	University level	29 (18)	6 (6)	23 (35)	
Ownership of house					
	Owned	108 (66)	96 (99)	12 (18)	<0.001
	Rented	47 (29)	0 (0)	47 (73)	
	Others	7 (5)	1 (1)	6 (9)	
Ownership of land					
	Yes	133 (82)	95 (98)	38 (58)	<0.001
	No	29 (18)	2 (2)	27 (42)	

Results are expressed as number (%) ;X2test was performed. ns=not significant

Table 3b.2 shows estimates of median energy expenditure in MVPA MET-minutes per week over 12 months as derived from the PYPAQ. The median total MVPA reported was 4753 MET-min/week with rural residents reporting higher total MVPA than urban residents (5914 MET-min/week vs 2373 MET-min/week; $p<0.001$). No significant difference was observed between the total MVPA of males (4602.04 MET-min/week) and females (4825.58 MET-min/week). Total MVPA was derived mostly from the occupation (32%), household (38%) and transport (22%) domains. LTPA (7%) and gardening (1%) were minor components of total PA. (Data not shown).

There was minimal vigorous intensity PA in all domains except for the transport domain among the rural residents where more than two thirds of the rural residents reported walking while carrying medium and heavy loads. Although males reported significantly higher MET-min/week for moderate intensity occupation related activities and leisure activities relative to women, women reported higher MET-min/week in the household domain.

Table 3b. 2: Descriptive statistics of total and domain specific physical activity derived from the Past Year Physical Activity Questionnaire (PYPAQ) in MET-min/week averaged over 12 months

PYPAQ domains MET-min/week	Total (n=162)	Rural residents (n=97)	Urban residents (n=65)	p	Male (n= 74)	Female (n=88)	p
	Median (Q1; Q3)	Median (Q1; Q3)	Median (Q1; Q3)		Median (Q1; Q3)	Median (Q1; Q3)	
Occupation							
Moderate PA	1426.6 (502.10; 2403.69)	1615.8 (1090.10; 2641.79)	426.7 (0; 2326.34)	<0.001	1921.73 (502.10; 2858.65)	1278.75 (461.97; 2283.14)	0.036
Vigorous PA	14.4 (0; 114.73)	78.5 (36.92; 224.42)	0 (0; 0)	<0.001	14.06 (0; 150.00)	21.92 (0; 110.77)	0.60
Household							
Moderate PA	1442.5 (682.00; 2180.32)	1857.6 (1296.17; 2505.94)	643.0 (348.46; 1379.60)	<0.001	937.36 (486.94; 1486.45)	1998.02 (1252.99; 2645.97)	<0.001
Vigorous PA	7.8 (0; 105.14)	23.4 (2.16; 166.15)	0 (0; 15.14)	<0.001	2.16 (0; 11.68)	34.61 (0; 186.92)	<0.001
Gardening							
Moderate PA	4.9 (0; 19.80)	12.3 (3.42; 24.57)	0 (0; 0.22)	<0.001	2.85 (0; 13.77)	5.92 (0; 23.65)	0.388

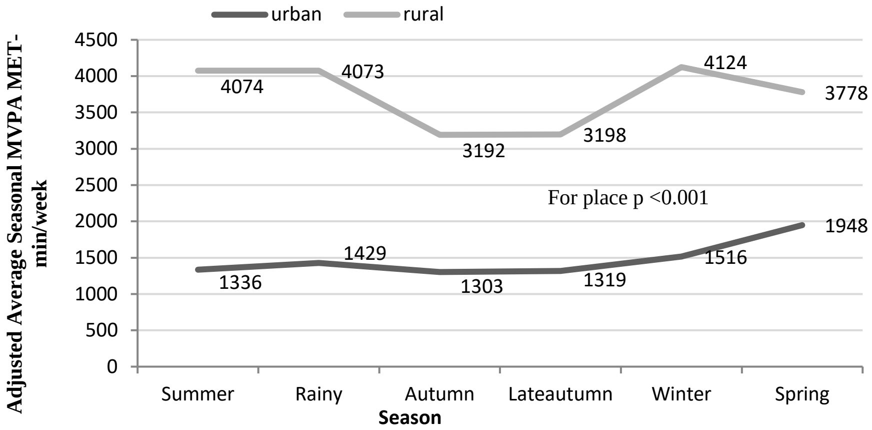
Travel							
Moderate PA	508.0 (314.48; 720.46)	562.1 (402.23; 802.85)	278.1 (134.08; 562.15)	<0.001	562.15 (343.62; 783.92)	458.31 (281.08; 644.13)	0.159
Vigorous PA	235.1 (22.50; 657.26)	476.0 (265.56; 914.46)	13.8 (0; 71.59)	<0.001	504.52 (21.65; 1123.27)	168.68 (22.50; 366.92)	0.001
Leisure							
Moderate PA	169.6 (56.54; 339.23)	339.2 (169.62; 339.23)	36.3 (0; 113.08)	<0.001	181.15 (102.12; 339.23)	169.62 (2.39; 254.42)	0.005
Vigorous PA	0 (0; 161.54)	6.5 (0; 339.23)	0 (0; 3.04)	<0.001	179.55 (1.08; 592.75)	0 (0; 0)	<0.001
PYPAQ –total MVPA	4753.4 (2977.49; 6382.29)	5914.5 (4647.88; 7161.45)	2373.4 (1080.60; 4217.88)	<0.001	4602.04 (2670.44; 7056.11)	4825.58 (3135.58; 6173.83)	0.541

Results are expressed as median (Q1:Q2)

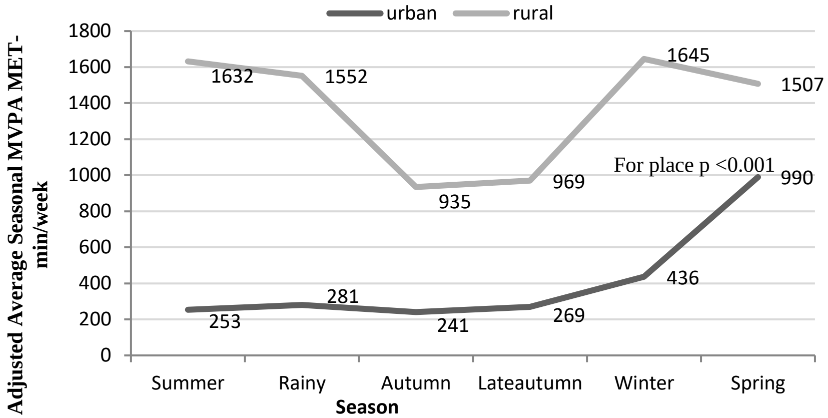
Seasonality in energy expenditure

shows the seasonal variation of MVPA MET-min/week for total PA (3b.1.a) for the rural and urban residents after adjusting for the potential confounding effect of age and gender. The rest of Figure 3b.1 (3b.1.b – 3b.1.f) shows the equivalent results for each PA domain individually. There were significant differences in total and domain specific average MVPA MET-min/week between the rural and urban residents in each season ($p<0.001$). Among the urban residents seasonal differences were noted only in household related PA (Figure 3b.1d, $p=0.03$). By contrast, in the rural residents statistically significant evidence of seasonal variation was evident for total MVPA ($p=0.0001$) and the occupation ($p=0.0001$), gardening ($p=0.0001$) and leisure time ($p=0.005$) domains but not for the transport or household domains.

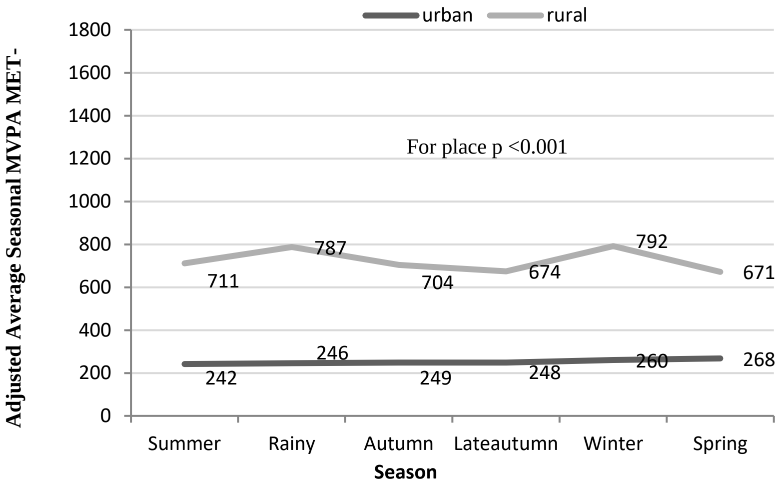
For the rural residents, the overall and occupation-related PA appeared to be highest in the summer, rainy and winter seasons and lowest in autumn and late autumn. Daily household activities and transport related PA domains did not show any significant differences between seasons whereas LTPA and gardening activities average MVPA peaked in the rainy season and decreased to a minimum in late autumn.


urban
rural
Adjusted Average Seasonal MVPA MET-min/week
4500
4000
3500
3000
2500
2000
1500
1000
500
0
4074
4073
3192
3198
4124
3778
For place p <0.001
1336
1429
1303
1319
1516
1948
Summer
Rainy
Autumn
Lateautumn
Winter
Spring
Season

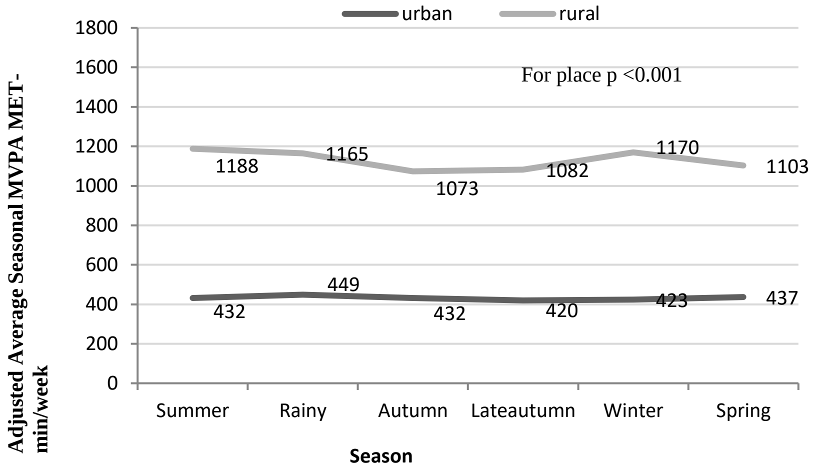
(a)


urban
rural
Adjusted Average Seasonal MVPA MET-min/week
1800
1600
1400
1200
1000
800
600
400
200
0
1632
1552
935
969
1645
1507
For place p <0.001
253
281
241
269
436
990
Summer
Rainy
Autumn
Lateautumn
Winter
Spring
Season

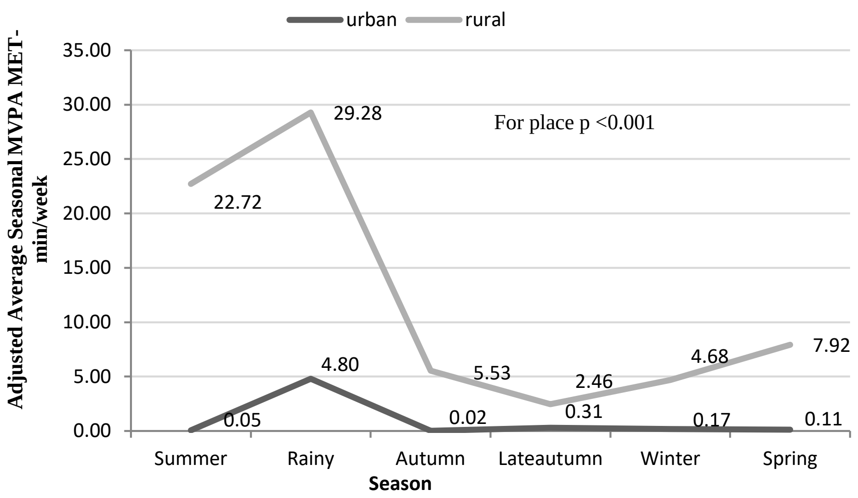
(b)


urban
rural
Adjusted Average Seasonal MVPA MET-min/week
1800
1600
1400
1200
1000
800
600
400
200
0
For place p <0.001
711
787
704
674
792
671
242
246
249
248
260
268
Summer
Rainy
Autumn
Lateautumn
Winter
Spring
Season

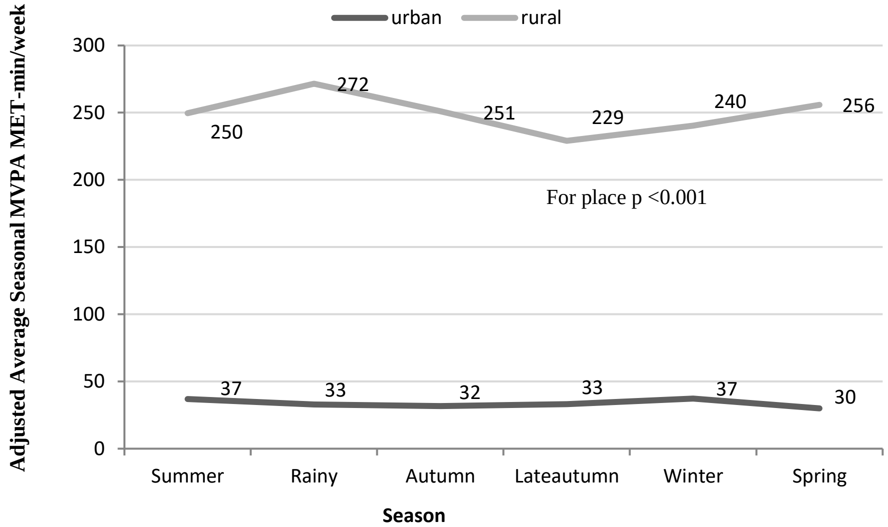
(c)


urban
rural
Adjusted Average Seasonal MVPA MET-min/week
1800
1600
1400
1200
1000
800
600
400
200
0
For place p <0.001
1188
1165
1073
1082
1170
1103
432
449
432
420
423
437
Summer
Rainy
Autumn
Lateautumn
Winter
Spring
Season

(d)



(e)



(f)

Figure 3b. 1: Mean MVPA MET-min/week of 6 seasons of Bangladesh by urban & rural adjusted for age and gender for: (a) all-domain of physical activity (PA); (b) occupation related PA; (c) transport related PA; (d) household related PA; (e) gardening related PA; (f) leisure time PA.

Seasonality in activity types by domain

In the leisure-time domain, each respondent was questioned about 20 separate types of physical activities. However, only five of these activities were recorded by more than 3% of respondents. These more common activities were walking for pleasure followed by cycling for pleasure, swimming, cricket and football (Figure 3b.2). The relative frequencies for each season are presented in Figure 3b.2. No one reported going to the gym or doing any muscle training and few reported aerobic classes (1.2%). Participation in swimming, and to some extent in football and cricket, seemed to be more common in the rainy and autumn seasons compared to other seasons.

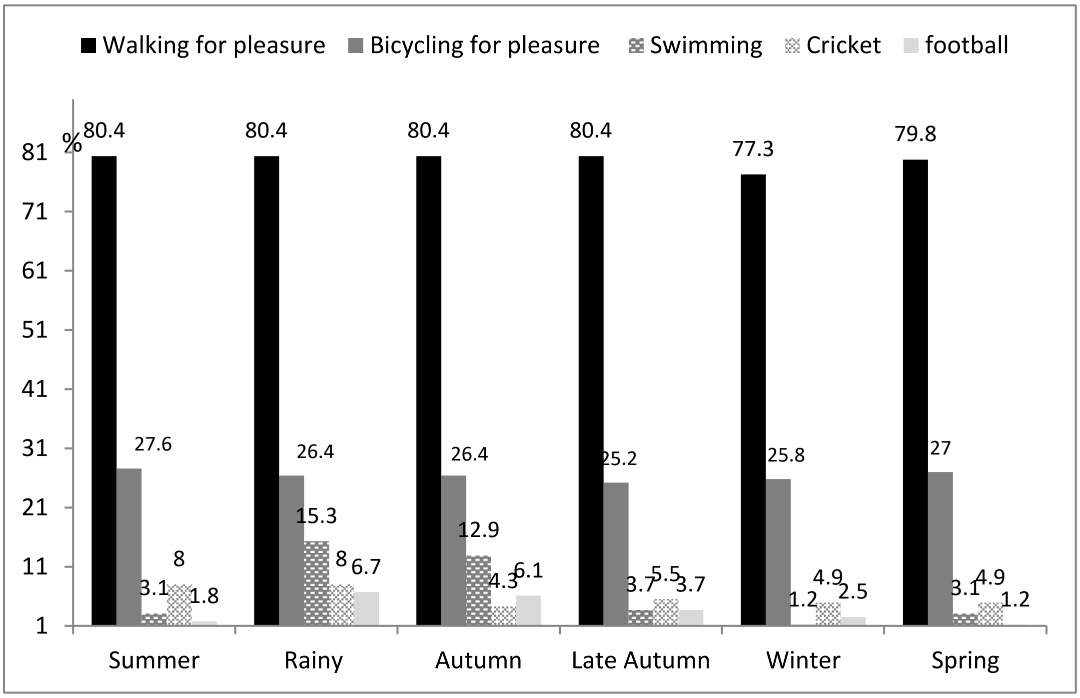


Figure 3b. 2: Most prevalent leisure –time physical activities in Bangladesh

The urban and rural residents showed substantial differences in LTPA participation (data not shown). While 100% of the rural residents participated in walking for leisure, only 50% of the urban residents participated in walking for leisure. Neither group showed seasonal variation in walking for pleasure. Whereas 41% of the rural residents participated in bicycling for leisure with little seasonal variation, cycling for pleasure was much less common in the urban residents with a noticeable seasonal divide. For the urban residents bicycling in spring, summer and the rainy season were reported by 6%, 8% and 5% of participants respectively, and by only 2%-3% of respondents in late autumn and winter. Swimming was most common in the rainy and autumn seasons with higher participation in the rural residents (22% and 19%) than in the urban residents (6% and 5%). By contrast, cricket and football were seasonal only in the rural residents: the urban residents played football all seasons (6% participation) except spring (3%) whereas the rural residents played football almost exclusively in the summer, rainy and autumn seasons (6%).

In the occupational domain out of 51 activities that were surveyed 12 showed seasonal changes in participation (data not shown). All of these were related to farming (e.g., poultry work, cleaning the barn, harvesting, processing rice, carrying seeds, etc.) producing the seasonality in occupation-related energy expenditure for the rural residents.

In the transport domain no activity displayed seasonal variation except of walking while carrying heavy load (>15kg). This was most common in winter, summer and rainy seasons (55%, 45% and 46% respectively) corresponding to harvest period (where crops are carried from field to farm or shopping destinations) and less common in autumn or late autumn (~20%). Similarly, many household activities were stable along the seasons. In the gardening domain, some activities such as planting trees, were more frequent in the rainy season (37%) as opposed to late autumn and winter (4%). (data not shown)

3b.4 Discussion

Main findings

The questionnaire described in this paper was designed to assess habitual, culturally relevant physical activities in different domains over the past year for working aged men and women residing in Bangladesh. We used this tool to compare the average MVPA of a group of urban residents (from a worksite in Dhaka) and a group of rural residents (from a village in northern Bangladesh; Thakurgaon). Marked differences were found in the patterns of MVPA between the rural and urban residents, with the urban participants reporting much lower levels of energy expenditure than the rural participants on average in every season. Seasonal variations in energy expenditure were statistically significant only among the rural residents. This seasonal variation in PA in the rural residents occurred in most PA domains with the exception of the household and transport domains. Despite relatively comfortable temperature in Thakurgaon during autumn (average 26-28° C) and late autumn (average 18-22° C) (279) when occupational PA of rural residents is low, LTPA did not peak. Prevalent LTPA in Bangladesh were those that are easily accessible; walking, swimming and bicycling, but the level of participation in these activities were substantially lower in the urban than in the rural residents and among women.

Seasonality

One of the strengths of the PYPAQ is its richness in information; it enables us to capture the variation of PA from season to season and provides information on the most common activity types. When surveillance of PA is based solely on a "usual week" or "the past week", it can be difficult to detect seasonal variations (It requires continuous and stable data collection over the entire year such as the Behavioral Risk Factors Surveillance (BRFSS) in the USA.

This study is the first year-round surveillance study of PA in Bangladesh and the first description of seasonal variations. Two previous WHO STEP surveys have collected PA data in Bangladesh. These used the Global Physical Activity Questionnaire (GPAQ) which asked respondents to recall their PA in a "usual week". The first survey was conducted from November 2009 to April 2010, covering late autumn to spring, with the more recent survey in 2013 covering winter and spring (Jan-March).

We observed statistically significant differences in average energy expenditure between seasons but only among the rural residents, and apparently dictated by the agricultural cycles. April-June (summer) is the time for various paddy planting and harvesting duties when farmers are highly engaged with moderate-to-vigorous farming related PA (260). In contrast, in autumn, while awaiting crops to ripen, there was a significant decline in occupational PA. Similar findings were found in a multi-site study of nine Asian rural areas (including Bangladesh) where PA was influenced by the timing of data collection. Specifically PA level was 20% lower when the survey was conducted during June to October compared to when the survey covered the rainy season, monsoon, and early winter (261). Surprisingly the recreational LTPA in the rural residents followed the occupational energy expenditure pattern. Also, LTPA declined in autumn despite average daily temperature being similar to summer when LTPA was high. Similarly, the temperature during the late autumn and winter in Bangladesh are quite pleasant for recreational activities but the recorded energy expenditure in LTPA was relatively low. While in western countries PA was generally found to be lower in winter compared with summer or autumn (280-282) there are exceptions. For example, extreme hot weather, such as in Arizona's summer, were shown to reverse the usual seasonal pattern of the wider USA (272). In the USA, according to the BRFSS yearlong survey, energy expenditure in spring and summer was 15%-20% higher than in fall and winter. This arose through a combination of higher intensity PA, an increased number of activities and an increased in duration of participation in each activity (281). In Bangladesh, the difference between summer and winter temperatures is less extreme and thus less likely to contribute to variation in PA. This may suggest that seasonal variation in PA in the rural residents maybe more strongly related to living the traditional agricultural calendar than to the weather.

In contrast to rural residents, the average MVPA MET-min/week for the urban residents in Bangladesh was quite stable throughout the year in all domains. One explanation could be the urban residents were selected from one workplace where occupation related PA is stable throughout the year. This is the typical pattern of PA when a person who lives in urban area holds a regular job with similar tasks throughout the year. Other industries and jobs such as construction workers and masons may be more susceptible to changes in the season. Indeed, even the availability of work and number of jobs held, could be subject to seasonal variation for some employment categories such as day laborers. It would therefore be worthwhile to assess seasonal variations in PA for a more representative sample of urban resident from a variety of work sites and professions to corroborate the flattened seasonal pattern. A recent study of university students in Dhaka showed that students were more concerned by poor lighting and a lack of convenient places to do PA (283) than weather conditions. Therefore one reason why the rate of participation in walking or cycling were so much lower in the urban residents may be the poor condition of footpaths, the heavy traffic and poor lighting (283). Swimming, in Bangladesh is an accessible PA with large areas of natural ponds and lakes, but these water-based centers may also be more accessible to the rural rather than the urban residents.

Differences in energy expenditure by domain and place

Overall, marked differences were found in the patterns of PA between the two study groups. The urban participants had much lower levels of activity than the rural participants which is consistent with other studies from Bangladesh (270, 271). A large scale Indian study, the ICMR- INDIAB study, also showed that the prevalence of physical inactivity was significantly higher in rural areas compared to urban areas (65.0% vs. 50.0%) (237). Furthermore, typical to low-income countries, we found that the occupation, household and transport domains were the major contributors to total PA (237, 261, 274). The very low contribution of LTPA to total PA, is of concern particularly for the urban residents. The urban residents reported lower prevalence of participation even in the most accessible form of activity, walking. Moreover, high-intensity activities were rarely recorded and there was no report of any planned exercise. Given the strong evidence linking exercise and fitness to cardio-metabolic health, LTPA should be promoted to all Bangladeshi to maximize their health benefits.

The average total MVPA MET-min/week of this study is comparable with previously published values from Past Year Total Physical Activity Questionnaire (PYTPAQ) in Canada (284) and the EPIC-Norfolk questionnaire (285), although this study showed higher values than those obtained from an Indian PAQ (MPAQ) (286). All these questionnaires assessed PA across the entire year but the questionnaires' formats are different. For instance, while our questionnaire has a list of prompted activities, PYTPAQ has an open question format. That is, participants were asked to recall all types of activities they did without prompts. This might lead to under reporting of physical activities that were less recently performed. The PYPAQ estimates were found higher than the GPAQ (271) because the PYPAQ inquires about 12 months physical activity and we express MVPA MET averaged across the whole year. On the other hand, GPAQ asks about one week of a whole year. This week can be the busiest or laziest week of a particular participant relative to long-term habits (276). Although our results showed higher MVPA MET-min/week than some of the short period questionnaires like GPAQ and International Physical Activity Questionnaire (IPAQ) (287, 288), other short period questionnaires produced quite similar results to ours. These include, for example, the Indian migration study physical activity questionnaire (IMS-PAQ) (94), Multi-Ethnic Study of Atherosclerosis (MESA) questionnaire (289) and the IPAQ conducted in Hong Kong's Chinese population (262). It is indeed challenging to compare PA between different populations because of the differences in the instruments used and the variable approaches for classifying PA into levels. Mealing et al. (290) and Brownson et al. (291) showed that the prevalence of meeting PA recommendations varied even in the same population when the same data are analysed by different PA scoring algorithms.

Strength and limitations

This study is the first to assess seasonal variations across all domains and in both the rural and urban context, however, some caution should be used when generalizing the findings. The urban sample was selected from one worksite and the rural sample from one geographic area. Like any PA questionnaire, PYPAQ has also some limitations. Firstly, we acknowledge the potential for recall bias when recording the frequency and duration of activities that occurred months prior. It was easier for participants to recall their near past PA than their PA in the more distant past. Participants were asked to recall the time they spend on certain activities in hours or minutes but in rural settings, people are less likely to watch the clock. Secondly, where statistically significant results were found in the study is by definition of adequate size, it is possible that there are further differences of practical importance between seasons which we have failed to detect in this study. Furthermore, while literacy rate in Dhaka is higher than in the Thakurgaon rural area (74% vs. 40%), our urban sample over-represented people from the highest education attainment. This may have introduced differential recall bias, with more accurate reporting in urban area than rural area, and therefore heightened the differences between study groups.

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3b.5 Conclusion

To our knowledge this is the first physical activity questionnaire in Bangladesh that is culturally and seasonally specific and reflects long-term participation in PA. Our findings highlight the strong seasonal variation in PA in a group of rural residents of Bangladesh and the much lower level of PA in a group of urban residents in all seasons.

As occupation and household related PA were the major contributors to total PA throughout, we encourage a longitudinal study using PYPAQ to investigate whether these domains alone can provide similar health benefits to the well–established benefit from LTPA and conditioning exercise documented in Western societies. Our results suggest that LTPA should be promoted to all residents in Bangladesh given the low prevalence of participation in this domain. However, the approach must be context and cultural specific (292); such as the WHO ACTIVE framework (293). For example, the promotion of LTPA in rural area in autumn and late-autumn, when occupational demand is low, repeated mass-participation events can be implemented at the community level in these seasons, in line with the Active Societies framework; whereas in urban areas the promotion of a safe and well-maintained environment with open public spaces that provide equitable access may be most needed. Together, such approaches will promote the health and well-being of Bangladesh residents at different locations.

Chapter 3c

Validation of a food frequency questionnaire as a tool for assessing dietary intake in cardiovascular disease research and surveillance in Bangladesh

The following paper constitutes Chapter 3c of the thesis and under review in Nutrition Journal

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3c. Validity of FFQ

This sub-chapter is presented as a form of journal article.

Abstract

Background: Cardiovascular disease (CVD) has emerged as a major public health concern in Bangladesh. Diet is an established risk factor for CVD but a tool to assess dietary intake in Bangladesh is lacking. This study aimed to validate a food frequency questionnaire (FFQ) using the 24-hour dietary recall method and corresponding nutritional biological markers among rural and urban population of Bangladesh.

Method: Participants of both genders aged 18-60 years were recruited from rural (n=97) and urban (n=65) areas. Two FFQs of 166 items were administered three-months apart, during which time three 24-hour dietary recalls were also completed. Participants were asked to recall their frequency of consumption over the preceding three months. Urine and blood samples were collected for comparison between FFQ-estimates of nutrients and their corresponding biomarkers. Methods were compared using unadjusted, energy-adjusted, de-attenuated correlation coefficients, 95% limits of agreement (LOA) and quartile classification.

Result: Fair to moderate agreement for ranking energy, macro and micronutrients into quartiles was observed (0.22 to 0.58; $p < 0.001$) except for vitamin D and zinc. The Bland Altman tests indicated the FFQ tends to underestimate most nutrients at low intakes and overestimate at higher intakes, while the correlation coefficients indicate acceptable correlation for most nutrients. Correlation coefficients of crude energy, macronutrient and common micronutrients including vitamin E, thiamine, riboflavin, niacin, pyridoxine, folate, iron, magnesium, phosphorus, potassium, and sodium were moderately good, ranging from 0.42 to 0.78; $p < 0.001$. In subgroup analysis, urban residents had higher correlation between the two dietary methods than rural residents. FFQ estimates of sodium (0.322; $p < 0.001$), vitamin D (0.20; $p = 0.017$) and iron (0.247; $p = 0.003$) correlated well with corresponding biomarkers.

Conclusion: This validation study demonstrated acceptable agreement for ranking dietary intakes from FFQ with 24-hour recall methods and some biomarkers and therefore can be considered as a tool to measure dietary intake for research and cardiovascular diseases (CVD) risk factors surveillance in Bangladesh.

Key words

Food Frequency Questionnaire, GPAQ, validity, dietary assessment, nutritional epidemiology, Bangladesh

3c.1 Introduction

Cardiovascular disease (CVD) is the leading cause of morbidity and mortality worldwide accounting for 31% of all deaths globally (29, 294) of which >75% occur in low- and middle-income countries (295). In Bangladesh, CVD has emerged as an important public health problem with 27% of all deaths are attributed to CVD (26). Ischemic heart disease (IHD) and stroke are now ranked as the top two causes of Years of Life Lost (YLL) in Bangladesh (130). A recent systematic review of prevalence studies in Bangladesh reported the overall weighted pooled prevalence of CVD was 5%, regardless of gender, region or type of CVD (296). The prevalence was found to be higher in urban areas (8% [95% CI: 3%‑14%]) compared to rural areas (2% [95% CI: 1%‑4%]) (296). Ischemic heart disease was the most prevalent CVD (21%) and stoke the least prevalent (1%) (296).

Many epidemiological studies have observed that diet plays an important role in the development and therefore, prevention of cardiovascular disease (297, 298). A diet rich in energy, total fat, saturated fat and sodium but relatively deficient in unsaturated fats, fruits and vegetables has been associated with the progression of CVD risk factors (299). Recent epidemiological studies have also shown associations between intake of B vitamins (folate, vitamin B6 and vitamin B12), vitamin D, antioxidants like β-carotene, vitamin C, and vitamin E, and a lowering of the risk of CVD (300, 301). Further research is needed to better understand the effect of these nutrients on CVD.

Diet is one of the most complex behaviours to measure and is considered the greatest challenge to nutritional epidemiology (302, 303). Different methods have been designed to assess diet and each of these methods has its own strengths and limitations

(302, 304, 305). The Food Frequency Questionnaire (FFQ) is one of the most common, and is considered a cost-effective and practical dietary assessment method for large samples, such as population based epidemiological studies (303, 304, 306). However, the FFQ asks individuals to recall information on all types of food from a defined list for a specific time period, including the frequency of consumption and the portion sizes of each item (307). Such detailed information is subject to random or systematic errors which can lead to biased estimation of the exposure –disease association (303). Therefore, an FFQ requires validation prior to or as part of dietary research or population monitoring.

Many FFQ have been validated and are widely used in studies in high-income countries, however, less work has been done validating FFQ in developing countries like Bangladesh (308, 309) where literacy level is low. It is recommended that a FFQ that was developed in one country should not be adapted for use in another country unless dietary habits are very similar (310). Two validity studies were conducted previously in rural Bangladesh, however, both FFQs were developed for a longitudinal study investigating arsenic exposure. The nationwide periodical surveys of non-communicable disease (NCD) risk factors in Bangladesh follow the WHO STEPS strategy where only fruit and vegetable intake have been assessed but individual habitual dietary intake was lacking (139). Although inadequate fruit and vegetable intake is one of the risk factors for CVD and necessary to monitor in risk factor surveillance, long-term habitual dietary surveillance that includes dietary intake of a broader range of foods is needed to study the progress toward prevention of prevalent chronic diseases.

Like other Asian countries, Bangladesh is undergoing nutritional transition due to urbanization and globalization (1, 57). With urbanization or migration to urban areas, there is a marked increase in consumption of fats and sugars and a decrease in the intake of fruit and vegetables. Increased access to and the popularity of fast food may also contribute to poorer diet quality (7). The parent Migration Study of Bangladesh is a large sibling-comparative study designed to investigate the differences in dietary intake among migrants from rural-to-urban area as opposed to their rural sibling . We intend to compare relatively all macro and micronutrients, and not only CVD risk factors such as fat, sodium but also CVD protective factors such as folate, vitamin E, C, β-carotene. In order to achieve the objective of the Bangladesh Migration Study, the FFQ previously designed for the Health Effects of Arsenic Longitudinal Study (HEALS) in Bangladesh (308) was adapted to the context of cardiovascular risk and the list of food items was extended. In the HEALS research, a 39 item FFQ was validated among 189 randomly selected HEALS participants using two 7-day food diaries (FD) (308). As even a subtle change in the design of an FFQ may affect the performance (304), validation of each instrument in the studied place is needed even if it is based on a previous questionnaire. The validity of the arsenic FFQ included only rural residents however, we required a tool validated for both rural and urban residents. Thus, a validity study was necessary and was performed prior to the data collection phase of the parent study. In this study we compared the FFQ against three 24-hour recalls and corresponding nutritional biological markers.

3c.2 Methods

3c.2.1 Study population

The validity study sample was recruited from rural (Satia village of Pirganj subdistrict of Thakurgaon District) and urban (Dhaka City) areas where the migration study was conducted. However, the samples for each study were different. Dhaka is the capital and one of the largest cities in Bangladesh, and the Thakurgaon District is situated at the northern part of Bangladesh (390 km from Dhaka). A total of 162 participants of both genders aged 18-60 years were included in the study and pregnant women, those who had an intellectual disability or those with any chronic medical condition which required dietary restriction were excluded. The minimum required sample size was calculated based on the desire to detect a Spearman correlation coefficient of 0.4 (309), items between the FFQ (in grams or calories) and the corresponding 24-hour recall to be statistically significant larger than 0 assuming $\alpha = 0.05$ with 80% power. As we have done the validation of FFQ in each region, the minimum sample size estimated was 55 urban and 55 rural (110 in total).

To select the rural participants, each household (HH) of Satia village was approached starting with the closest house on the left hand side of the main road, and then the next-nearest HH was visited and recruitment continued until the sample size was reached. From each HH only one eligible person was selected. If a house was unoccupied or an eligible participant was not present at the time of a visit, the house was revisited later that day or on another day. Urban participants were selected using convenience sampling from faculty and staff of a worksite, Bangladesh University of Health Sciences (BUHS), Dhaka. There are twelve distinctive work grades from the highest grade (e.g., professor) to the lowest position (e.g., cleaner). To incorporate all grades into the study, the recruitment methods included email and poster advertisements on the university campus as well as face-to-face conversation to recruit those who were illiterate or have no access to email.

At the first meeting, participants received written materials that described the study aims and procedures. Those who provided written consent were recruited to the study. Participants were informed that during the study they were able to complain or to withdraw at any time using the study telephone number. For illiterate participants, research assistants read the materials line-by-line and explained the content in simple words. The research assistant ensured that illiterate participants understood the study properly and made the decision to participate independently. The study obtained ethics approval from the Western Sydney University Human Research Ethics Committee (HREC # H11145) and the BUHS Ethical Review Committee.

3c.2.2 Study design

Validity was assessed by comparing the energy and nutrient intakes derived from the FFQ against the 24-hour recall method and biomarkers. The FFQ and 24-hour recall were administered via an interview conducted by trained research assistants, who were equipped with interview manuals and the same reference portion size for standardisation. During field interviews, the nutritionist or field supervisor conducted random visits for quality control. The details on the sequence of administration of the dietary survey methods and blood and urine collection are shown in Figure 3c.1

Figure 3c. 1: Scheme of the dietary assessments and blood and urine sampling for one participant

Measures	1st week of 1st month							1st week of 2nd month							1st week of 3rd month							1st week of 4th month						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7
FFQ	x																					x						
24-hour recall								x							x							x						
Urine								x																				
Blood								x																				

3c.2.3 The food frequency questionnaire

A semi-quantitative FFQ was administered twice, three months apart. The FFQ was based on a questionnaire designed for use in the arsenic study in Bangladesh (308), which was adapted to be used in the migration study to assess CVD risk. The FFQ used in the arsenic study (308) contained 39 food items while the present questionnaire consists of 166 typical food items of rural and urban Bangladeshis, including unique foods of the northern area (Annexure 4.2). The additional food items were included based on previous studies (unpublished) conducted by BUHS team of nutritionists using 24-hour recall method in Pirganj and Dhaka city. The final food list was generated after checking the availability of foods at local markets and extensive discussion with nutritionists, local research assistants and residents. Food items are listed in the major food groups such as: cereals, pulses & legumes, milk & milk products, meat & fish, egg, vegetables, fruits, oils & fats, beverages and snacks or fast food. Participants were asked to recall their frequency of consumption over the preceding three months. Participants reported the frequency of consumption of each food on the basis of five levels of frequencies : never, daily, weekly, monthly or times over the entire three months. To obtain an estimate of portion size, participants were shown common household portions (standard serving size of bowl, plate, spoon, ladle, glass) and photographs (i.e size of fruits, fish, meat) and were asked to report portion sizes in relation to these standards. All completed questionnaires were checked by the study nutritionist for accuracy and completeness. As data was collected by trained research assistants, a small scale of missing data or inconsistency was found. If any error was found, research assistants contacted the participants by phone for clarification.

3c.2.4 The 24-hour dietary recalls

Three 24-hour dietary recalls were conducted one month apart as a reference measure. As the 24-hour recall method collects data on a single day, it cannot describe the usual nutrient intake because of day-to-day variability. However, multiple 24-hour recalls provide a reasonable estimate of a person’s usual nutrient intake (305, 311). Each participant reported all types and amounts of foods and beverages consumed in the previous day. In order to represent all days of the week the first 24-hour recall was collected on a weekday, and the second or third 24-hour recall was performed after weekend in a random manner. For estimating portion size of consumed foods, participants were encouraged to view commonly used household portions or photographs. The same reference portion sizes were used as for the FFQ. In this study, an average intake in these three recalls was taken to compare the intake of the last FFQ, which covered the period of three 24-hour recalls.

3c.2.5 Biomarkers

A venous blood sample was drawn by a trained phlebotomist after a minimum 8 hour overnight fast. A morning spot-urine was also collected. Venous blood (~8 ml) was obtained by venipuncture following standard procedures and the urine sample was collected (10 ml) in a sterile container. Blood samples were collected in a plain tube

(~8 cc), allowed to clot for 30 minutes and then serum was separated by centrifugation for 10 min at 3000 rpm. After that, three aliquots of at least 600 µl of serum were collected. For urban participants the blood sample was collected at the BUHS Lab and rural participants were invited to attend a camp for blood and urine sample collection. Samples from rural participants were transferred to the core laboratory at BUHS in a box containing dry ice to maintain a suitable temperature. All samples were preserved in a freezer (-70 C) until laboratory assays were carried out. All tests were performed at the BUHS laboratory.

The laboratory applied strict quality control techniques and measured the following biomarkers: serum folates (ng/ml), 25-OH vitamin D (ng/ml), ferritin (ng/ml), triglyceride (mg/dl) and sodium (mmol/L), potassium (mmol/L), protein (mg/dl), and creatinine (mg/dl) in urine. Whole blood (~2 ml) was taken in a 2 mg/ml EDTA vial for measurement of complete blood count (CBC), measured by flow cytometry method. Serum triglyceride was measured by the GPO-PAP method/ TGL Flex reagent cartridge, (Cat No: DF 69A) and serum [25(OH)D] (Cat No: EIA-5396) and ferritin (Cat No: EIA 1872) were measured using ELISA kits [DRG Instruments GmbH, Germany (Thermo Scientific Multiskan® FC- Filter-based microplate photometer/Finland)]. Serum folate (Cat No: L2KFO2, 200 tests) was measured using chemiluminescence immunoassay (CLIA) (Immulite® 2000 / Siemens, USA). Urine samples were used for urine R/M/E analysis by microscopic examinations, urinary total protein by UCFP method/ UTP Flex reagent cartridge, Cat No: DF 26, urinary creatinine by CRE2 method/ CRE Flex reagent cartridge, Cat No: DF 33B, and urinary electrolytes by NOVA4 biomedical analyzer.

3c.2.6 Calculation of nutrient intake

The Food Composition Table (FCT) of Bangladesh (312) was used to derive nutrient and energy estimates from dietary data. Among the 166 food items, nutrient composition of 122 foods were taken from FCT of Bangladesh. Food composition data from other sources (313-317) were used when food items were not available in this FCT. If nutrient values of cooked local foods (30 food items) were unavailable in FCTs, we obtained weighed recipes and a group of nutritionists, including the first author, calculated the nutrient values of those foods. As most of the data in the FCTs are raw food, yield factor was used for cooked food items to convert the quantity of cooked food into raw quantity. Yield factors[20] were either taken from the FCT of Bangladesh or calculated by weighing before and after cooking following a standard recipe. Estimates of grams of food consumed per day were calculated by multiplying the frequency of consumption of food items by the portion size. This was then converted into daily nutrient intake by using FCTs. For a given nutrient, intakes of all food items were then summed to obtain the total nutrient intake for each individual. Nutrient estimates from FFQ were calculated using this method:

Daily nutrient intake= Σ [(frequency of consumption of a food per day) X (portion size of that food) X (amount of that nutrient in 100 g)]

[20] Yield factors gives information on weight changes during the preparation of foods, for example, water absorption during cooking of rice or water loss during the preparation of meat.

3c.2.7 Statistical analysis

Mean (±SD) and median with 25th and 75th percentiles were calculated for energy and nutrients assessed by FFQs and the three 24-hour recall. Correlations between the two methods were measured using Spearman's Rank Correlation Coefficient (or Pearson's Correlation for normally distributed data) for unadjusted; energy-adjusted; age, gender, place adjusted; age, gender, place & energy-adjusted and de-attenuated data. We compared the average of three 24-hour recalls to the last FFQ (after 3 months). Comparisons were made for the total sample, by gender and place of residency. Energy-adjusted estimates of nutrient intake were obtained by the residual method (318). De-attenuated correlation was calculated to remove within-person variability in 24-hour recalls using this formula: $r_t = r_0\sqrt{1+r/n}$. Here, r_0 is the observed correlation between FFQ and 24-hour recalls, where r is the ratio of intra and inter subject variation measured from the three 24-hour recalls and n is the number of days of dietary recalls (n=3) (319). Further, non-parametric partial correlation was used to calculate an age, gender and place adjusted estimate of the correlation. Unadjusted and energy-adjusted correlation was computed between estimates of nutrient intake derived from the FFQ and the corresponding biomarkers. We have presented correlations for the total sample and for the subgroups urban residents and rural residents separately. Furthermore, we categorized the distribution of unadjusted and energy-adjusted nutrient intakes into quartiles and then used weighted kappa to assess the agreement between FFQ and 24-hour recall. The proportion of subjects categorized in the same quartile by both methods (agreement), in contiguous quartiles (adjacent agreement), and in opposite and/or one quartile apart (disagreement) were estimated. To assess the agreement between two methods the Bland-Altman method was used; first the difference in estimated intake between two methods (FFQ and 24-hour recall) were plotted against the average of the estimated intake of these measures [(FFQ+24-hour)/2]. The 95% limits of agreements (LOA) (mean± 1.96 SD) were calculated for visual illustration of the range of agreement between the two methods. Second, the slope coefficient from the linear regression was calculated for each nutrient. The dependent variable was the difference between dietary intake instruments and the independent variable was the average of two methods. Thus, the slope coefficient estimates the degree of over-or-under estimation over the level of intake. To interpret the kappa statistic the following standards were used: 0-0.20 = poor; 0.21-0.40 = fair; 0.41-0.60 = moderate/acceptable; 0.61-0.80 = substantial; 0.81-1.0 = near perfect (248). Socioeconomic classifications were made according to the 2006 per capita Gross National Income (GNI) and according to World Bank (WB) calculations (320). The groups were: low-income, US$ ≤ 905 or Bangladeshi Taka (BDT) ≤ 5360; lower-middle-income, US$ (906–3595) or BDT (5361–21270); upper-middle-income, US$ (3596–11115) or BDT (21271–65761); and high-income, US$ ≥11116 or BDT ≥65762. All p values presented were two tailed and p-values less than 0.05 were considered to provide statistically significant evidence of association. Data was analyzed using SPSS (version 23) statistical software.

3c.3 Result

We recruited 162 participants, of those 90% (146 participants) completed the final FFQ and three 24-hour recall method and formed the validity study. The main reasons for attrition were moving to another place, quitting their job and an unwillingness to participate due to being too busy. The mean age of the validity study participants (total n=146, rural n=94 and urban n=52) was 35 (SD±9) years. Slightly over half of the participants were female (55%), 20% had no schooling and the majority (88%) were married. Mean (±SD) BMI and waist circumference were 22.68 (±3.33) and 81.73 (±11.96), respectively. Significant differences were noted between the urban and rural populations for age, education, and income group. The rural group had more participants in the more than 40 years age group than the urban group (32% and 8%, respectively), while the urban group had more participants in the 31-40 age group (50% and 39%, respectively). A higher proportion of urban residents had completed high-school or attained a university level of education (70% and 47%, respectively). Nearly significant differences were observed for BMI and waist circumference between the rural and urban groups, indicating higher BMI among urban residents.

Table 3c.1 presents the mean (±SD) intake for energy and macronutrients, and median with 25th and 75th percentiles for micronutrients derived from two FFQ (baseline and three months apart) and three 24-hour recalls. Estimates of energy and nutrients by FFQ were all higher than those obtained from 24-hour recalls but the percentage of energy measures agree. The comparison between the two FFQ suggest that for most nutrients we obtained stable estimates at baseline and after three months except for vitamin E, vitamin C, folate, calcium, phosphorus and zinc.

Table 3c. 1: Energy and nutrient intake per day by FFQ and 24-hour recall

Nutrients	FFQ- 1 (n=162)	FFQ- 2 (n=146)	FFQ Average	24-hour recall- 1 (n=151)	24-hour recall- 2 (n=152)	24-hour recall- 3 (n=148)	24-hour recall Average
Mean±SD							
Energy (kcal)	3525±1307	3668±1560	3562±1175	2400±838	2486±923	2722±1074	2533±795
Protein (g)	137±65	144±75	140±58	82±33	86±45	98±57	88±31
(% energy)	16±4	15±3	16±3	14±3	14±4	14±5	14±2
Fat (g)	72±31	74±33	73±27	55±27	49±27	51±24	52±21
(% energy)	19±6	20±8	20±6	22±10	20±11	19±10	20±9
Carbohydrate (g)	566±234	586±268	569±211	385±174	414±192	457±212	419±168
(% energy)	65±8	65±8	65±7	64±11	66±13	67±11	66±10
Median (Q1; Q3)							
Vitamin A (μg)	950.90 (575.83; 2235.12)	1360.05 (608.46; 2221.67)	1449.28 (694.15; 2166.75)	319.01 (92.41; 1437.14	182.90 (40.02; 641.75)	227.95 (29.20; 632.51)	442.93 (195.13; 835.35)
β carotene (μg)	5326.82 (2993.34; 8607.47)	4770.12 (2016; 10380.42)	5822.77 (3183.43; 9430.86)	951.21 (85.53; 6599.98)	667.29 (93.44; 3893.51)	2281.37 (161.19; 6667.31)	2806 (1286.01; 5582.71)
Vitamin D (μg)	1.32 (0.62; 2.72)	2.01 (0.98; 3.70)	2.00 (1.00; 3.24)	0.13 (0; 1.37)	0 (0; 1.30)	0 (0; 1.37)	0.69 (0.02; 1.45)
Vitamin E (mg)	9.53 (7.36; 12.05)	7.66 (5.64; 9.71)	8.78 (6.82; 11.07)	5.12 (4.26; 7.37)	5.03 (3.89; 6.81)	5.41 (4.22; 6.69)	5.19 (4.33; 7.03)
Vitamin C (mg)	338.55 (193.07; 517.51)	318.81 (127.78; 502.35)	350.72 (170.02; 497.02)	48.59 (23.49; 100.30)	69.25 (21.67; 136.00)	100.83 (40.97; 188.80)	86.75 (50.66; 142.84)
Thiamine (mg)	2.06 (1.51; 2.79)	2.32 (1.23; 3.95)	2.39 (1.60; 3.31)	0.80 (0.58; 1.07)	0.92 (0.66; 1.40)	0.99 (0.67; 1.51)	0.97 (0.73; 1.34)
Riboflavin (mg)	1.75 (1.16; 2.44)	1.20 (1.10; 3.16)	1.94 (1.24; 2.72)	0.76 (0.46; 1.06)	0.73 (0.48; 1.12)	0.87 (0.55; 1.55)	0.89 (0.65; 1.20)

Table 3c.1 (continue)

Nutrients	FFQ- 1 (n=162)	FFQ- 2 (n=146)	FFQ Average	24-hour recall- 1 (n=151)	24-hour recall- 2 (n=152)	24-hour recall- 3 (n=148)	24-hour recall Average
Median (Q1; Q3)							
Niacin (mg)	30.22 (23.70; 47.19)	36.72 (22.04; 56.02)	35.16 (26.95; 48.59)	17.45 (13.01; 22.00)	17.10 (12.86; 24.16)	17.83 (12.60; 25.55)	18.94 (14.71; 23.45)
Pyrodixine (mg)	2.86 (2.15; 3.99)	3.44 (1.78; 5.36)	3.27 (2.01; 4.54)	1.62 (1.06; 1.87)	1.60 (1.13; 2.31)	1.94 (1.13; 2.95)	1.76 (1.25; 2.31)
Folate (μg)	465.02 (327.63; 605.31)	723.28 (274.93; 1183.36)	617.19 (339.89; 860.65)	156.24 (102.04; 240.96)	209.45 (126.84; 324.59)	251.31 (131.79; 512.09)	229.89 (153.12; 377.71)
Calcium (mg)	1153 (688.69; 1970.40)	823.90 (488.07; 1288.51)	1056.88 (685.51; 1559.15)	427.23 (231.06; 815.12)	309.34 (154.17; 679.85)	30.13 (169.16; 747.60)	475.40 (275.62; 701.47)
Iron (mg)	21.20 (15.56; 30.14)	20.28 (12.08; 29.77)	20.60 (16.25; 30.85)	11.64 (8.83; 18.01)	11.29 (7.55; 15.33)	12.20 (8.40; 18.81)	12.99 (9.55; 16.67)
Magnesium (mg)	599.45 (444.62; 791.89)	541.01 (373.81; 838.58)	598.21 (455.96; 798.48)	343.97 (223.41; 445.03)	368.97 (255.36; 517.58)	412.56 (260.21; 850.46)	418.55 (277.61; 580.10)
Phosphorus (mg)	1852.25 (1333.25; 2802.22)	1842.62 (1138.26; 2630.94)	1905.78 (1383.15; 2524.96)	1031.98 (772.92; 1423.72)	1032.96 (733.01; 1499.55)	1130.87 (747.31; 1620.75)	1146.59 (829.16; 1450.35)
Potassium (mg)	4024.04 (3104.68; 5015.33)	3854.38 (2349.68; 5501.72)	3944.25 (2955.11; 5085.23)	1895.62 (1472.81; 2477.37)	2060.48 (1465.06; 2854.32)	2233.78 (1620.63; 3461.53)	2177.80 (1628.46; 2700.35)
Sodium (mg)	807.66 (559.97; 1193.12)	842.97 (421.99; 1372.02)	885.05 (613.65; 1206.70)	405.77 (225.98; 713.32)	404.98 (210.65; 704.52)	399.39 (226.04; 771.00)	472.70 (311.32; 705.45)
Sodium (mg)[a]	7221.55 (5783.86; 9147.38)	7435.54 (5479.35; 9579.75)	7474.04 (5788.20; 9226.78)	6809.13 (5450.99; 8523.87)	6879.05 (5441.08; 8682.33)	6839.14 (5613.07; 8996.42)	6900.24 (5596.41; 8961.52)
Zinc (mg)	310.01 (114.70; 639.61)	494.12 (208.31; 1117.18)	443.77 (238.59; 912.38)	13.28 (8.61; 23.83)	13.84 (9.01; 176.32	16.16 (10.43; 734.97)	241.38 (13.92; 755.01)

Results are expressed as mean (±SD) and median (Q1; Q3); [a] included cooking salt

Table 3c.2 and 3c.3 shows shows the correlation coefficients between the final FFQ and average of the three 24-hour recalls for the total group and stratified by urban and rural groups, respectively. All unadjusted correlations were statistically significant except for vitamin D and zinc. Correlations for unadjusted intakes were in the range of 0.015 (for vitamin D) to 0.776 (for carbohydrate) and energy-adjusted correlations were generally lower except for fat and vitamin E, and in range of -0.017 (for calcium) to 0.686 (for fat). De-attenuated correlations were higher than unadjusted and energy-adjusted, and significant for all nutrients except for vitamin D, with a range of 0.017 (for vitamin D) to 0.801 (for carbohydrate). After adjusting for socio-demographic variables, the value of unadjusted and energy-adjusted correlation varied and the range were 0.138 to 0.576 and 0.016 to 0.617, respectively. Stratification by place of residency indicated similar or higher correlation (unadjusted and de-attenuated) in urban than rural participants. In the case of energy-adjusted correlation, fat (0.755 vs 0.521) and carbohydrate (0.642 vs 0.430) showed better correlation in urban than rural individuals, while the value for protein declined for urban individuals and increased in rural. For other nutrients the same pattern was observed in the urban individuals compared to rural, as seen in the unadjusted correlation.

Correlations between nutrient intake derived from the final FFQ and average of three 24-hour recall were also calculated for men and women (Additional File 3). The correlation coefficient for crude data varied from -0.112 (vitamin D) to 0.676 (pyridoxine) in men and 0.083 (vitamin D) to 0.789 (carbohydrate) in women. In both genders, adjusting for total energy improved the correlation in some nutrients like fat, vitamin D etc. but decreased the value of most nutrients. However, all correlations increased after de-attenuation, ranging from -0.139 (vitamin D) to 0.752 (carbohydrate) in men and 0.096 (vitamin D) to 0.828 (carbohydrate) in women.

Table 3c. 2: Correlation coefficient of energy and nutrients between FFQ and three days of 24-hour dietary recall

Energy and Nutrients	Unadjusted[a]	Energy adjusted[b]	Age, gender, place adjusted[c]	Age, gender, place & energy adjusted[c]	De-attenuated
Energy (kcal)	0.739**	-	0.481**	-	0.769**
Protein (g)	0.555**	0.182*	0.490**	0.210*	0.612**
(% energy)	0.131	-	-	-	-
Fat (g)	0.424**	0.686**	0.576**	0.617**	0.443**
(% energy)	0.800**	-	-	-	-
Carbohydrate (g)	0.776**	0.530**	0.396**	0.475**	0.801**
(% energy)	0.663**	-	-	-	-
Vitamin A (μg)	0.384**	0.145	0.147	0.084	0.427**
β carotene (μg)	0.309**	0.306**	0.204*	0.278**	0.338**
Vitamin D (μg)	0.015	0.060	0.174*	0.048	0.017
Vitamin E (mg)	0.479**	0.635**	0.494**	0.538**	0.488**
Vitamin C (mg)	0.399**	0.064	0.186*	0.016	0.706**
Thiamine (mg)	0.598**	0.385**	0.471**	0.370**	0.688**
Riboflavin (mg)	0.516**	0.142	0.394**	0.101	0.565**
Niacin (mg)	0.553**	0.186*	0.434**	0.183*	0.618**
Pyrodixine (mg)	0.738**	0.210*	0.388**	0.129	0.786**
Folate (μg)	0.537**	0.043	0.243**	0.015	0.588**
Calcium (mg)	0.326**	-0.017	0.149	-0.043	0.359**
Iron (mg)	0.530**	0.157	0.248**	0.110	0.568**
Magnesium (mg)	0.708**	0.118	0.330**	0.064	0.765**
Phosphorus (mg)	0.665**	0.070	0.456**	0.047	0.722**
Potassium (mg)	0.617**	0.243**	0.468**	0.229**	0.657**
Sodium (mg)	0.342**	0.281**	0.410**	0.276**	0.400**
Sodium (mg)[d]	0.625**	0.551**	0.510**	0.536**	0.628**
Zinc (mg)	0.161	0.206*	0.138	0.167*	0.188*

Correlation was performed between Last FFQ & average of 24-hour
***Correlation is significant at the 0.01 level; *Correlation is significant at the 0.05 level*
[a] *Pearson correlation coefficient used for energy and macronutrient; Spearman rank correlation coefficient was used for micronutrients*
[b]*Spearman rank correlation coefficient was performed;* [c]*Non-parametric partial correlation was performed*
[d]*included cooking salt*

Table 3c. 3: Correlation coefficient of energy and nutrients between FFQ and three days of 24-hour dietary recall among urban and rural

Energy and Nutrients	Unadjusted[a]		Energy adjusted[b]		De-attenuated	
	Urban	Rural	Urban	Rural	Urban	Rural
Energy (kcal)	0.642**	0.554**	-	-	0.667**	0.589**
Protein (g)	0.659**	0.426**	0.093	0.213*	0.739**	0.473**
(% energy)	0.467**	0.224*	-		-	
Fat (g)	0.558**	0.565**	0.755**	0.521**	0.576**	0.608**
(% energy)	0.606**	0.570**	-	-	-	
Carbohydrate (g)	0.429**	0.554**	0.642**	0.430**	0.457**	0.582**
(% energy)	0.589**	0.436**	-	-	-	
Vitamin A (μg)	0.323*	0.148	0.294*	0.093	0.381**	0.164
β carotene (μg)	0.385**	0.211*	0.414**	0.248*	0.412**	0.233*
Vitamin D (μg)	0.482**	0.082	0.279*	-0.053	0.569**	0.099
Vitamin E (mg)	0.688**	0.334**	0.657**	0.380**	0.704**	0.343**
Vitamin C (mg)	0.306*	0.186	0.233	0.045	0.338*	0.204
Thiamine (mg)	0.392**	0.548**	0.240	0.428**	0.455**	0.637**
Riboflavin (mg)	0.594**	0.334**	0.515**	0.044	0.682**	0.364**
Niacin (mg)	0.581**	0.424**	0.175	0.160	0.663**	0.478**
Pyrodixine (mg)	0.555**	0.420**	0.266	0.143	0.593**	0.457**
Folate (μg)	0.319*	0.218*	0.369**	-0.012	0.341*	0.240*
Calcium (mg)	0.327*	0.143	0.198	-0.088	0.354**	0.159
Iron (mg)	0.480**	0.299**	0.184	0.110	0.524**	0.323**
Magnesium (mg)	0.648**	0.286**	0.256	0.070	0.708**	0.314**
Phosphorus (mg)	0.593**	0.502**	0.178	0.018	0.690**	0.543**
Potassium (mg)	0.466**	0.542**	0.147	0.270**	0.496**	0.576**
Sodium (mg)	0.612**	0.355**	0.325*	0.234*	0.710**	0.363**
Sodium (mg)[d]	0.719**	0.361**	0.681**	0.445**	0.722**	0.419**
Zinc (mg)	0.300*	0.110	0.051	0.211*	0.338*	0.130

Correlation was performed between Last FFQ & average of 24-hour
***Correlation is significant at the 0.01 level; *Correlation is significant at the 0.05 level*
[a] Pearson correlation coefficient used for energy and macronutrient; Spearman rank correlation coefficient was used for micronutrients
[b]Spearman rank correlation coefficient was performed
[d]included cooking salt

Table 3c.4 lists kappa statistics. The weighted κ value for the unadjusted data ranged from -0.049 (vitamin D) to 0.582 (energy) and were statistically significant for energy and all nutrients except vitamin D and zinc. For the majority of nutrients, the weighted κ values reduced after energy adjustment, however, increases in values were observed for fat, β carotene, vitamin D, vitamin E and sodium. Although κ statistical significance was maintained for macro nutrients, some vitamins (vitamin D, vitamin C and folate) and minerals (calcium, magnesium, phosphorus and zinc) showed non-significant κ statistics. For the unadjusted data, the classification of subjects into same quartile varied from 19% (vitamin D) to 53% (energy) (mean 41%); the exact agreement added to adjacent agreement varied from 61% (vitamin D) to 95% (energy & carbohydrate) (mean 82%); and the disagreement mean was 18%. For energy-adjusted data, the exact agreement mean was 34% and the exact agreement added to adjacent agreement mean was 73%.

Table 3c. 4: Agreement (weighted k) and cross-classification of quartiles of energy and nutrient intakes

Nutrient	Unadjusted data				Energy-adjusted data			
	Weighted *k* (95% CI)	Exact agreement (%)	Exact agreement + Adjacent (%)	Disagreement (%)	Weighted *k* (95% CI)	Exact agreement (%)	Exact agreement + Adjacent (%)	Disagreement (%)
Energy (kcal)	0.582 (0.495; 0.669)	53.42	95.2	4.79	-			
Protein (g)	0.455 (0.354; 0.555)	45.89	87.67	12.33	0.137 (0.020; 0.255)	30.14	69.87	30.14
Fat (g)	0.231 (0.116; 0.345)	31.51	76.03	23.97	0.477 (0.381; 0.572)	43.84	91.79	8.22
Carbohydrate (g)	0.542 (0.452; 0.632)	49.32	94.53	5.42	0.353 (0.249; 0.458)	36.99	83.62	14.38
Vitamin A (μg)	0.263 (0.150; 0.377)	33.56	78.68	21.23	0.135 (0.015; 0.255)	33.56	70.55	29.45
β carotene (μg)	0.229 (0.107; 0.351)	38.62	73.79	26.21	0.269 (0.151; 0.388)	40.41	76.71	23.29
Vitamin D (μg)	-0.049 (-0.163; 0.064)	19.18	60.96	39.04	0.030 (-0.086; 0.147)	25.34	65.75	34.25
Vitamin E (mg)	0.27 (0.156; 0.384)	34.97	78.33	21.68	0.377 (0.274; 0.481)	39.04	84.25	15.75
Vitamin C (mg)	0.246 (0.134; 0.359)	33.56	75.34	24.66	0.052 (-0.071; 0.175)	28.77	65.76	34.25
Thiamine (mg)	0.412 (0.309; 0.515)	41.10	86.99	13.01	0.292 (0.180; 0.403)	36.30	80.14	19.86
Riboflavin (mg)	0.346 (0.238; 0.454)	39.04	82.19	17.81	0.150 (0.028; 0.272)	34.25	71.24	28.77
Niacin (mg)	0.371 (0.263; 0.480)	41.38	82.07	17.93	0.175 (0.052; 0.298)	34.93	72.6	27.40

Pyrodixine (mg)	0.549 (0.460; 0.638)	51.37	93.15	6.85	0.143 (0.023; 0.263)	32.19	69.86	30.14
Folate (µg)	0.331 (0.225; 0.438)	38.36	79.46	20.55	0.060 (-0.062; 0.182)	30.14	64.39	35.62
Calcium (mg)	0.228 (0.109; 0.346)	36.30	74.66	25.34	0.016 (-1.00; 0.133)	23.40	62.44	33.56
Iron (mg)	0.359 (0.246; 0.473)	43.15	80.14	19.86	0.181 (0.059; 0.303)	35.62	72.61	27.40
Magnesium (mg)	0.523 (0.427; 0.620)	51.37	90.41	9.59	0.096 (-0.024; 0.216)	32.19	66.44	33.56
Phosphorus (mg)	0.447 (0.344; 0.551)	45.89	88.36	11.64	0.055 (-0.063; 0.173)	28.08	62.33	37.67
Potassium (mg)	0.433 (0.334; 0.533)	42.47	88.36	11.64	0.236 (0.119; 0.354)	34.93	77.4	22.60
Sodium (mg)[a]	0.469 (0.361; 0.571)	51.03	85.51	14.48	0.440 (0.327; 0.552)	50.00	82.88	17.12
Zinc (mg)	0.096 (-0.30; 0.223)	31.51	68.5	31.51	0.142 (0.018; 0.267)	32.88	69.87	30.14
Mean	0.349	40.62	81.92	18.07	0.191	34.15	73.03	26.68

Weighted k was performed between Last FFQ & average of 24-hour; [a]included cooking salt

Table 3c.5 presents the agreement between methods including the mean difference with 95% LOA and coefficient of regression of the difference on the average. For energy intake, the mean difference between two methods was 1134.78 Kcal with wide limits of agreement (-1020.16 Kcal to 3289.72 Kcal), with a positive slope coefficient indicating overestimation by FFQ at higher levels of intake. Similar results were observed for other nutrients. Positive slope coefficients indicate the agreement between methods worsens with increasing intake, while a negative slope indicates that agreement was worse at a lower level of intake. Most of the coefficients are positive which indicated that FFQ provided a greater overestimation at higher intakes. The visual inspection of the Bland-Altman plots also indicated a systematic pattern of overestimation at higher intakes and an underestimation at lower intakes of energy and protein intake by FFQ. Bland-Altman plots for the other nutrients showed similar trends except fat, carbohydrate, vitamin A, beta carotene, vitamin D, vitamin E, magnesium, sodium and zinc where the pattern showed over and under estimation with increase of intake (Supplementary File Annexure 3c.1).

Table 3c. 5: Limit of Agreement (LOA) and beta coefficients between FFQ and average of 24-hour recall methods

Energy and Nutrients	Mean difference (FFQ- 24-hour)	95% LOA lower; upper	β	p
Energy (kcal)	1134.78	-1020.16; 3289.72	0.712	<0.001
Protein (g)	55.91	-65.39; 177.21	1.00	<0.001
Fat (g)	21.88	-37.35; 81.11	0.594	<0.001
Carbohydrate (g)	167.69	-172.68; 508.06	0.485	<0.001
Vitamin A (μg)	932.99	-1787.16; 3653.14	0.937	<0.001
β carotene (μg)	2368.08	-8557.61; 13293.77	0.236	0.03
Vitamin D (μg)	1.37	-4.29; 7.03	0.037	0.79
Vitamin E (mg)	2.1	-4.52; 8.72	0.494	<0.001
Vitamin C (mg)	223.27	-169.69; 616.23	1.09	<0.001
Thiamine (mg)	1.56	-1.22; 4.34	1.14	<0.001
Riboflavin (mg)	1.19	-1.28; 3.66	0.897	<0.001
Niacin (mg)	20.57	-17.26; 58.39	1.27	<0.001
Pyrodixine (mg)	1.78	-1.36; 4.92	0.955	<0.001
Folate (μg)	475.16	-455.43; 1405.75	1.02	<0.001
Calcium (mg)	402.07	-809.52; 1613.66	0.745	<0.001
Iron (mg)	7.9	-14.09; 29.89	0.607	<0.001
Magnesium (mg)	125.73	-448.92; 700.38	-0.134	0.13
Phosphorus (mg)	741.66	-707.99; 2191.32	0.90	<0.001
Potassium (mg)	1738.13	-1450.18; 4926.44	0.96	<0.001
Sodium (mg)	340.72	-732.52; 1413.96	0.239	0.037
Sodium (mg)[a]	537.41	-5020.09; 6094.91	0.282	0.001
Zinc (mg)	252.93	-1703.89; 2209.75	0.118	0.38

Table 3c.6 presents the distribution of mean or median daily concentration of biomarkers and the correlation coefficient for the FFQ estimates and its corresponding biomarkers. In the unadjusted correlation, significant positive correlation was found for vitamin D, iron and sodium. However, negative significant correlation was found for iron with hemoglobin and total protein with urinary total protein and creatinine. Regarding energy-adjusted correlation, negative correlation turned to positive except for total protein intake with urinary protein level. Vitamin D intake was no longer significantly correlated with blood levels after energy adjustment while the correlation coefficient increased from -0.053 to 0.189 for folate. For sodium, correlation decreased from 0.322 to 0.227, though was still significantly correlated. We also checked correlation between first 24-hour intake and biomarkers and similar findings were observed.

As seen in the subgroup analyses by place, iron agreed best with its biomarkers both in urban (0.396) and rural (0.247) areas. While unadjusted correlation for folate was better for urban areas, following energy adjustment, this was reversed to show better agreement in rural individuals. Sodium intake correlated better in urban than rural areas (0.224 vs 0.204). For the unadjusted correlation, significant positive correlations were found with their biomarkers for Vitamin D, iron and sodium in women and sodium alone in men. After energy adjustment iron was significantly correlated with serum ferritin in men.

Table 3c.6: Level of biomarkers and correlation between FFQ-derived estimates and corresponding biomarkers

FFQ-estimated daily dietary intakes	Biomarkers	Levels of biomarkers		Total		Urban		Rural		Men		Women	
		Mean (±SD)	Median (Q1; Q3)	Unadjusted	Energy adjusted	Unadjusted	Energy adjusted	Unadjusted	Energy adjusted	Unadjusted	Energy adjusted	Unadjusted	Energy adjusted
Vitamin D (µg)	Serum 25 (OH) vitamin-D (ng/ml)	64.13 (±29.98)	58 (42; 82)	0.201*	-0.018	0.095	0.087	-0.012	0.139	-0.086	-0.242	0.432**	0.193
Vitamin B9 (µg)	Serum folate (ng/ml)	9.73 (±4.77)	7.89 (6.18; 12.80)	-0.053	0.189*	0.323*	0.139	0.169	0.316**	-0.089	0.229	0.020	0.134
Iron (mg)	Serum ferritin (ng/ml)	50.90 (±38.52)	40.30 (25.60; 61.60)	0.247**	0.003	0.163	-0.165	0.060	0.204	0.194	0.255*	0.249*	-0.170
Iron (mg)	Hemoglobin (g/dl)	11.47 (±1.94)	11.20 (9.92; 12.80)	-0.426**	0.082	0.396**	-0.215	0.247*	-0.034	-0.344**	0.209	-0.568**	0.157
Fat (g)	Serum triglyceride (mg/dl)	144.32 (±113.92)	110 (81; 156)	0.162	-0.059	0.103	0.161	0.085	0.017	-0.020	-0.168	0.174	-0.007
Sodium (mg)	Urine sodium (mmol/L)	140.65 (±53.71)	135 (103; 168)	0.322**	0.227**	0.178	0.224	0.245*	0.105	0.380**	0.224	0.329**	0.236*

Potassium (mg)	Urine potassium (mmol/L)	45.56 (±18.37)	45.56 (33; 54)	0.005	0.05	0.131	0.015	0.040	0.035	0.066	-0.003	0.050	0.008
Total Protein (g)	Urine total protein (mg/dl)	121.30 (±94.73)	96 (59; 160)	-0.250**	-0.035	-0.004	-0.158	-0.172	0.002	-0.224	-0.151	-0.291	0.065
Total Protein (g)	Urine creatinine (mg/dl)	106.97 (±92.95)	78 (36; 136)	-0.186*	0.013	0.058	-0.042	0.063	0.054	-0.124	0.031	-0.230*	0.019

Results are expressed as mean (±SD) and median (Q1;Q3); Correlation was performed between Last FFQ & biomarkers

3c.4 Discussion

The aim of this study was to validate FFQ against an average of three 24-hour recalls and several nutritional biomarkers among urban and rural Bangladeshis. We found fair to moderate agreement for ranking energy, macro and micronutrients into quartiles indicating the FFQ is good for studying relationships with nutrients intakes. The Bland Altman tests indicate the FFQ tends to underestimate most nutrients at low intakes and overestimate at higher intakes relative to the 24-hour recall, while the correlation coefficients all indicate good correlation and similar results to other studies (308, 309, 321-323). In subgroup analyses, most of the nutrients displayed higher correlation among urban residents compared to rural residents. The energy-adjusted correlation hugely differed between men and women. In relation to biomarkers, FFQ estimates of sodium, folate and iron, which are important CVD protective/risk factors, correlated better with corresponding biomarkers.

A major challenge of the validity study is to select a suitable reference method to test the target instrument, as no gold standard exists in dietary intake measurements (319, 324). While other possible dietary methods for the validation study such as weighed or estimated food records exist, these were not feasible due to the high level of illiteracy of rural residents and the burden and increased cost involved. It is a limitation that both methods rely on memory compared with a prospective food record. However, the 24-hour recall has several strengths as it is inexpensive, quick to administer and provides detailed information on food intake. Furthermore, the 24-hour recall method requires only short-term memory and can be used for populations in which illiteracy is common (305, 309, 311). It is considered by some to be more objective than FFQ and its administration does not alter the usual diet as a prospective food record might (305). In a review article it was reported that about 22% studies used 24-hour recall as reference method, which was similar to weighed records (25%) and food diary (26%) (311). Moreover, in this study we have conducted a 24-hour recall for three days and on both weekend and weekdays to record day-to-day variability.

There was overestimation of total energy and nutrient intake by FFQ compared to 24-hour recalls, which is in line with previous research (309, 319, 322). It may be that when people are asked to recall the frequency of several foods, they tend to overestimate the actual intake (319, 325). Another possible explanation could be that a large number of food items were included in this FFQ to cover usual and local foods of the city and northern part; however, asking more foods might inflate estimates of total intake when summing across foods (309, 326). Moreover, there is always a possibility of over-reporting of serving size or frequency of consumption because of biases such as recall and social desirability which could lead to overestimation of nutrient estimate of FFQ.

Correlation coefficients observed in this study were higher than those found in two earlier studies assessing the validity of FFQs for arsenic against food records in rural area of Bangladesh (308, 321). Another comparable study is the Indian Migration Study (IMS) because its objective and study design were quite similar to our parent migration study. The correlation coefficient observed in the IMS FFQ validation study (309) were similar to our study. For example, correlation for fat intake in the IMS was 0.42 which is very similar to our study (0.424).

After energy adjustment, the correlation coefficient in the present study was improved for fat and vitamin E, however, the majority of nutrients showed decreased correlation. When the correlation coefficient increases after energy adjustment, the variability of nutrient intake is related to energy intake. On the other hand, the correlation coefficient decreases if the variability depends on systematic error of under and overestimation

(319). The Bland-Altman plots demonstrated an overestimation at higher intakes and an underestimation at lower intakes. For protein, a linear trend of overestimation was observed in the Bland-Altman plot and a remarkable decline of correlation coefficient was observed in urban area after energy adjustment, though rural area showed significant fair correlation. However, fat, which is one of the predictors of CVD, showed better correlation after energy adjustment.

As demographic variables are always controlled in epidemiological studies as confounders, we also controlled for age, sex and place for unadjusted and energy-adjusted correlation. The adjustment is justified because the between-person variation in dietary intake due to these variables usually increases the observed correlation between methods (324). However, this study showed fair to moderately significant correlation for most of the nutrients even after adjustment. We also corrected day-to-day within person variation by calculating de-attenuated correlations for energy and nutrients, which were usually higher than their original values. On average, the de-attenuated correlation values were 0.55 for the total sample and higher in the urban (0.55) than rural sample (0.38). The concordance coefficients decreased for weighted κ statistic after categorization of energy and nutrient intake into ordinal level than continuous. However, fair agreement (mean κ= 0.349) was observed between two methods which was similar to that reported in other validation studies (327, 328). When allocating nutrient intake into quartiles for the two different methods and looking at cross-classification; subjects were correctly classified in the exact and adjacent quartile with an average of 82% for unadjusted data and 73% for energy-adjusted data. The weighted kappa statistics thus indicate good agreement between methods and these results are comparable to other studies (319, 322, 327).

As all methods of dietary assessment are subject to error (302, 311), we compared FFQ estimates with biological markers. Of the nutrients we considered, folate, sodium and iron estimated by FFQ showed a higher correlation coefficient with the respective biomarker. For folate, the observed energy-adjusted correlation, around 0.20 for total sample and >0.30 for the rural subset, suggest a responsiveness of the biomarker to the dietary intake. These correlations were in the range of previous studies (303, 329-332). Importantly, our FFQ can provide a valid measurement of folate intake, one of the protective factors of CVD (333, 334). Previous studies often failed to get statistically significant correlations between dietary folate intake estimated by FFQ and serum folate. The reasons given for inconsistent findings were due to the influence of information bias, various sample sizes and different laboratory techniques for folate level estimation (329).

Concerning correlation between sodium intake and urinary sodium, fair correlation was observed for total sample. A systematic review on validation of FFQ by sodium biomarker (335) also reported the same magnitude of correlation to that obtained in the present study. This systematic review reported that if the FFQ does not include an estimate of discretionary salt use (in cooking or at the table), sodium intake assessed by the FFQ was on average 30% (range 2% to 52%) underestimated than that measured in 24-hour urine collections (335). Another study on the validation of a FFQ for CVD using biomarkers, also found poor correlation as no question was included on table salt intake (303). In our study we asked about cooking salt in addition to calculating salt derived from food. The intake of cooking salt was estimated by dividing the monthly usage by the number of family members. When we run our analysis without including cooking salt, the correlation with sodium was poor, as mentioned in the above review (335). After including cooking salt, significant and fair correlation with urinary sodium were found. In the sub-group analysis, energy-adjusted correlation with urine sodium was better for urban than rural residents, as observed with the correlation between FFQ and 24-hour recalls. A possible explanation for these results might be that in rural areas sometimes people use unpacked salt, which may have reduced the accuracy of reporting cooking salt intake in rural participants. Another reason could be the literacy level, but the small sample size in each educational sub-group precluded any sub analysis. However, the correlation observed in this study may be improved if a 24-hour urine measure was employed. Although multiple 24-hour urine collections and assessed for completeness using a suitable method (such as PABA) is recommended (335), we were unable to do this due to feasibility. As sodium intake is related to CVD risk, further study should be done following this recommendation. .

Iron overload and deficiency has been proposed to be a potent risk factor for CVD, by different mechanisms (336, 337). In this study, a fair, unadjusted correlation was observed between dietary iron intake and serum ferritin. This was reduced to a poor, energy-adjusted correlation for the total sample. When we stratified by gender, the energy-adjusted correlation was fair (r=0.255; p=0.04) for men and poor for women. A similar finding was observed in another study where energy-adjusted correlation between FFQ intake and serum ferritin was poor (r=0.007) for women (303). Further sub-group analysis revealed that energy-adjusted correlation was moderate (r=0.426) for rural men whereas it was poor for both urban men and women (Data not shown). We also tested correlation with haemoglobin, where negative, fair correlation was found with iron intake for the total sample and after stratifying by place. However, the correlation became positive but poor after energy adjustment. One explanation for this low correlation could be that iron absorption and storage depends on various factors, which were not measured here, such as bioavailability of heme and non-heme iron, interaction with absorption inhibitors and enhancers, infection or inflammation and physiological (menstruation, hookworm) or non-physiological (blood donation) iron loss (303, 324).

Recent epidemiologic studies have demonstrated association between vitamin D insufficiency and the risk of CVD (338). Although in the unadjusted correlation, vitamin D showed poor (0.201) but significant correlation, it decreased after energy adjustment. The reason for the low correlation might be that plasma vitamin D concentration is influenced by not only diet but also exposure to sunlight, which acts as a confounder (303, 324). Correlation between protein and potassium intake with their corresponding biomarker showed poor correlation, which was not surprising as we did not use recovery biomarkers.

Ideally, in the validation of dietary methods study, recovery biomarkers such as doubly labelled water for energy and markers of potassium, sodium and nitrogen in 24-hour urine for potassium, sodium and protein intake would be used (303, 324, 339). Although recovery biomarkers are considered the gold standard, the expense, availability of these biomarkers and technical expertise required limited their use in this study.

Other limitations of this study include that we did not consider nutrient retention factors for cooked foods and data on dietary supplements was not collected. Also, although our reference for recall period is short and therefore cannot be affected by seasonal variations, seasonal availability of some fruit and vegetables may lead to a variance in intake of certain vitamins and minerals during the 3 months. The arsenic study of Bangladesh showed small seasonal variation for total energy, protein and carbohydrate intake but larger variation for vitamin D, beta carotene and vitamin A (321). In the current study, reproducibility results were not reported which could be addressed in further studies. Moreover, although we have reported total fat and carbohydrate, we could not include different types of fat (poly unsaturated, saturated etc.) and carbohydrate (complex, refine etc.) intake in the study because of the limited information at FCT to conduct such a sensitive classification for validity. Finally, as our urban sample is selected from a worksite; caution should be applied regarding generalization to all urban residents, although our sampling methods ensured urban residents from all SES were included.

The main strength of this study is that it validated the FFQ against multiple 24-hour recall measures and biomarkers, among both rural and urban participants. The previous FFQ used in Bangladesh was validated against one other dietary intake measurement (food diary) without any biomarkers, and only on rural Bangladeshis (308, 321). The recommendation of the previous FFQ (308) study was to include detailed food lists, which was achieved in the current FFQ. We have expanded the food list with frequently consumed food in Bangladesh and included local foods as well. Another strength of this study is the large sample size, including both genders.

3c.5 Conclusion

To the best of our knowledge, this is the first validity study of an FFQ for CVD in Bangladesh using multiple measures of dietary assessment. This validation study demonstrated acceptable agreement for ranking dietary intakes from FFQ with 24-hour recall methods and some biomarkers. In the future, this FFQ can be considered as a tool to monitor dietary intake in large-scale, epidemiological trials in both rural and urban Bangladesh. However, continued research is needed to enhance its validity with recovery biomarkers and to assess reliability.

Chapter 4

Lifestyle risk factors and their impact on metabolic markers of cardiovascular diseases in rural-to-urban migrants compared with their non-migrant siblings

4. Sibling-pair comparative study

4.1 Introduction

Cardiovascular disease (CVD) is a major health problem across the world accounting for 31% of all deaths (29, 294) and over 60% of the coronary heart disease (CHD) burden on a global basis occurs in developing countries, particularly in Asia (8). Demographic transition (from declining fertility and increased life expectancy) accompanied by urbanisation are driving transformations in lifestyle such as nutrition habits and physical activity (PA), and increasing the risk of CVD (57, 340, 341). The global burden of disease (GBD) study 2017 illustrated that the Disability Adjusted Life Years (DALYs) due to energy-dense diets high in sugar, fat and sodium and low in fruits and vegetables; and physical inactivity have increased by 16.4% and 20.1% from 2007 to 2017, respectively (28). As a comparison, in 1990, low physical activity was not included in the top 20 listed global risk factors for high-middle sociodemographic index (SDI) countries; yet, it became the 15th leading risk factor in 2017 (28). In the case of Bangladesh, unhealthy diet and physical inactivity ranked 3rd and 11th as leading risk factors for CVDs, respectively (136).

For the last few decades Bangladesh has been undergoing transformation in its demographic, socio-economic and political structure resulting in rapid urbanisation caused mainly by rural-to-urban migration (174). At present, the country considers rural-to-urban migration and urbanisation to be its most pressing population problems. The urban population is growing so fast that it will rise from its current level of 53 million people to 112 million in 2050 (37). According to the Bangladesh Population and Housing Census 2011, the national rural-to-urban migration rate was 4.29 per 1000 population but was nearly seven times higher for Dhaka, the capital city, where the rate was 29.5 per 1000 population (126).

Diet and Physical Activity

The rapid urbanisation of Bangladesh is likely to have profound implications for its population health profile. It has been long observed that the processes of urbanisation associated with migration lead to dietary changes, in particular diets high in saturated fat, trans fat, sugar and salt, and low in fibre (57, 144). It can be that fat and sugar are the cheapest source of calories and more accessible than fibre containing food like fruits and vegetables (57). Moreover, increased access to and the popularity of fast food may also contribute to poorer diet quality, particularly among the city's affluent class (7). In the case of the low income group, their diets comprise of cheap food which is made from unhealthy ingredients like palm oil and salt and available in street shops or vendors (342).

Changes in socioeconomic status towards higher levels, environment infrastructure and urbanisation have impacted on daily physical activity in developing countries. While urban living is providing many amenities, unplanned development in the urban areas has created an environment that is prohibitive and unsafe for physical activity (57, 343). Other major environmental influences that have caused declines in physical activity levels include shifting from work-related physical activity to sedentary work due to modern labour-saving technology, greater use of vehicles and increases in screen based leisure entertainment such as TV and computers (55, 56). A recent census of Bangladesh showed that now people are far less dependent on agriculture and related work with agricultural work decreasing remarkably from 50% in 2001 to 30% in 2011 (126). The rural areas are no longer confined to food production but are now a source of labour for urban areas. Most economic migrants to urban areas choose more remunerative non-agricultural jobs and most of them are sedentary. For example, nowadays, rural poor migrants are more employed in readymade garment factories in Dhaka and other metropolitan areas (128). In addition, some data from the Bangladesh Bureau of Statistics (BBS) (344) showed that vehicle use has been increasing in Bangladesh similar to the trend observed in developed countries since the early 1970s. Moreover, Bangladeshis often use the most popular and cheap vehicle called the 'rickshaw', a three-wheeler passenger cart, even for a short distance trip, that could have been made on foot. A small scale study conducted in rural and urban area in Bangladesh have shown that active commuting is higher in rural (58%) than urban (33%) areas (345). At the same time, recreational activities, like sports and dancing, have not yet become common in developing countries like Bangladesh, resulting in substantially fewer physical activity opportunities all together (346, 347). Moreover, the urban environment is also creating crowded, unplanned living environments that do not allow for the creation and maintenance of open green spaces favourable for physical activities such as walking, jogging or cycling, which are accessible to all and have proven benefits for maintaining cardiovascular health (57).

Metabolic risk factors

It has been suggested that two unhealthy behaviours, namely physical inactivity and an unhealthy diet, lead to four key metabolic/physiological changes; raised blood pressure, overweight/obesity, hyperglycemia and hyperlipidemia (7). The GBD study demonstrated that most developing countries have been experiencing an increasing prevalence of unhealthy behaviours accompanied by underlying metabolic/ physiological changes in CVD risk factors (348). Both these types of risk factors, often coexist in the same individual, and work synergistically to increase the individual's total risk of developing acute vascular events such as heart attack and stroke (4). The three WHO STEPs surveys of Bangladesh (2006, 2010 and 2013) reported clearly that not only behavioural risk factors (e.g. low intake of fruit/vegetables and physical inactivity) but also metabolic risk factors (e.g. overweight, hypertension and documented diabetes) have been increasing (139).

Acculturation

When a person migrates to the city s/he faces numerous changes, not only in the socio-cultural environment but also in lifestyle such as diet and physical activity (175, 349). Nevertheless, changes in lifestyle depend on degree of acculturation. For example, a study on Japanese individuals migrating to the U.S. showed that those who get the opportunity to maintain a Japanese lifestyle, have a more gradual migration experience (i.e. in changes in diet and other lifestyles). Despite this lack of apparent acculturation, the risk of diabetes amongst Japanese individuals living in urban areas of the U.S. is two to three times higher than in Japanese individuals living in Japan (117). South Asians (SAs) in the UK showed more risk factors for CVD (e.g. obesity, hypertension, dyslipidemia, higher fasting glucose) compared to their siblings in India, potentially due to adoption of an urban or western life style (8). Another migration study in the UK conducted in SAs, including Bangladeshis, showed that 87% of Bangladeshi migrants did not meet the guidelines for physical activity compared to Europeans (52%). The probable explanation is the cultural value and attitudes of SAs that prevent them getting involved in sports and physical activity, particularly among females (156). So, the relation between acculturation and health status is complex and varies from population to population.

Acculturation takes place not only after crossing international boundaries but also moving from rural to urban areas (109). However, studies on acculturation and migrant health have largely focused on movement between countries (96, 97, 105, 108) whereas very few have looked at rural-to-urban migration (120, 161). A variety of proxy measures are used as an indicator of acculturation in population studies such as length of residency, place of birth, age at migration or language use by migrants (96, 97, 108). Proxy measures are quick and easy to perform; however, it is difficult to quantify complex and multidirectional acculturation with simple static indicators such as these (96, 97, 108).

Rationale

In case of internal migration, various studies also showed that rural-to-urban migrants had higher prevalence of CVD risk factors (8, 86, 146, 350, 351). In India, rural-to-urban migrants reported higher energy intake, macronutrient (carbohydrate, protein and fat) and sugar intake compared with non-migrant and rural counterparts, but contrary to expectation migrant and urban participants consumed 80% higher fruit and vegetables than rural participants (93). Studies from Guatemala (84) and China (352) showed that migrants consumed more fat and cholesterol than non-migrant rural counterparts and the Chinese study also found lower energy and dietary fibre intake in migrants. Similarly, studies demonstrate that not only urban people but also migrants from rural-to-urban areas had lower levels of physical activity than rural people (86, 353). This may suggest that moving to an urban area may lead to a reduction in physical activity, which increases the risk of metabolic CVD risk factors. However, most of the studies conducted on the effect of migration are cross-sectional and comparisons were made between independent rural, urban or migrant samples (86, 87, 354), so, causal inference cannot be made.

Although Bangladesh is undergoing a rapid urbanisation process there is currently no study that has focused on internal migration in Bangladesh. Few cross-sectional surveys have been done where dietary intake and physical inactivity are compared between rural and urban areas. The Bangladesh NCD risk factors survey reported that low physical activity, defined as performing less than 600 MET per week, was higher in urban (28.9%) areas than rural (25.1%) but indicated small differences by area of residency (188). On the other hand, in this survey, fruit and vegetable consumption was assessed and no striking difference was found (188). This may be because the measurement of diet in the survey is not sensitive, prone to error and a proper validated tool is needed. Another nationwide survey, the Household (HH) Income & Expenditure Survey 2010 (HIES), found calorie intake per capita per day to be similar in rural and urban areas (2344 kcal and 2244 kcal respectively), but red meat and sugar intake was higher in urban areas when compared with rural areas. Inversely, the vegetable intake was higher in rural areas than in urban areas (355). However, these reports are descriptive in nature and therefore do not provide any information on possible socio-economic moderators, such as income, education or occupation, that may further explain the rural-urban differences. Moreover, the rural-urban comparison cannot examine the effect of migration as the cultural, genetic and lifestyle background of the migrants and the host population may not be similar (146).

In Chapter 2 We analysed the Urban Health Survey (UHS) 2006 to examine the proportion of CVD risk in migrants. This analysis showed that levels of CVD risk factors increase with a longer period of stay in an urban area among migrants, however this study did not cover important behavioural (diet, physical activity) and metabolic (diabetes, central obesity, dyslipidemia) risk factors due to unavailability of data. We also could not compare the health status of migrants with the benchmark i.e. similar people of origin.

Migration is further complicated as it may be influenced by 'selection of migrants' according to higher or lower risk of health and disease (146, 178). In addition, as most of the migration was due to economic reasons, it is assumed that those with better health or lifestyle and socioeconomic status are more likely to be able to afford migration. In this scenario, the lifestyles and health profile of high SES individuals have already been determined in the pre-migration period (178).

In order to guide interventions that aim to reduce the health risks associated with migration, it is necessary to understand what the changes in lifestyle were among migrants in a particular place, and whether such changes were associated with increased risk of metabolic CVD risk factors. Understanding the changes in lifestyle may provide an indication not only to the underlying causes of increases in the reported prevalence of chronic conditions in the general urban population, but may also identify sub-populations at a greater risk due to migration (93).

A sibling-pair comparative study can better address the limitations of the above mentioned cross-sectional comparisons in Bangladesh, without the cost associated with following up migrants for many years to detect changes. A sibling-pair study is designed to limit the background characteristics or behavioural differences between rural and migrant groups as it assumed the sibling pairs share many health determinants from their past, including environmental and genetic factors, hence the differences observed at present between the migrant and the rural sibling represent divergence from the "shared lifestyle".

The present study aimed to assess differences in dietary intake and physical inactivity among migrant and non-migrant rural siblings, and to determine their impact on metabolic risk factors of cardiovascular diseases.

4.2 Objectives

1. To compare the prevalence of physical inactivity among rural-to-urban migrant and non-migrant rural siblings
2. To compare the dietary intake (calorie, macronutrient and food group) among rural-to-urban migrant and non-migrant rural siblings
3. To compare the metabolic CVD risk factors (overweight & obesity, hypertension, diabetes, lipid profile) among rural-to-urban migrant and non-migrant rural siblings
4. To explore whether education, income and occupation type modified the differences in dietary intake, physical inactivity and metabolic risk factors between rural-to-urban migrants and non-migrant rural siblings
5. To find out whether the proportion of dietary components, physical inactivity and metabolic risk factors vary by length of residence in the urban environment and the degree of acculturation

4.3 Methods

4.3.1 Ethics approval

This study was approved by the Western Sydney University Human Research Ethics Committee (HREC # H11056) and Bangladesh University of Health Science Ethical Review Committee. Written consent was obtained from all participants before data collection.

4.3.2 Study design

A sibling-pair comparative study (86) was designed comparing rural-to-urban migrants to their rural siblings. The best study design is a follow up study where changes of behavioural or metabolic risk factors from before and after migration can be measured over time. However, logistical difficulties in identifying and tracing migrants, particularly in countries where National Population Registry Systems do not exist or are poorly covered, prevent the use of such a superior study design. To overcome this, a sibling-pair comparative study was designed for this study. The advantage of this design is primarily the "control" for the genetic predisposition of the CVD and possibly the environmental influences within the family and the surrounding environment, as it was assumed that the lifestyles prior to migration might be similar between the two siblings but would divert once one sibling migrated to an urban area and the other remained residing in the original rural area. In this respect, it is a better comparison than a cross-sectional study of two independent samples.

4.3.3 Place of study

This study was conducted in the capital city, Dhaka and Pirganj subdistrict/upazila of Thakurgaon district of Bangladesh, which were selected conveniently.

Dhaka is the capital and one of the largest cities in Bangladesh. The population of Dhaka Metropolitan stands around 8.9 million (356). The population in Dhaka is growing by an estimated 4.2% per year, one of the highest rates amongst Asian cities.

The Thakurgaon district is situated in the northern part of Bangladesh. This district has five sub-districts: Baliadangi, Haripur, Pirgonj, Ranisankail and Thakurgaon Sadar. This study was conducted in the Pirganj subdistrict which has an area of 354 square kilometres and consists of 10 unions (details in Annexure 4.1) with the total number of residents reaching 2,43,535 million based on the 2011 census. The reason behind choosing this area is that it is far from Dhaka (390 km) and only 11.4% of urbanisation processes have occurred in this subdistrict, hence it maintains its rural characteristics.

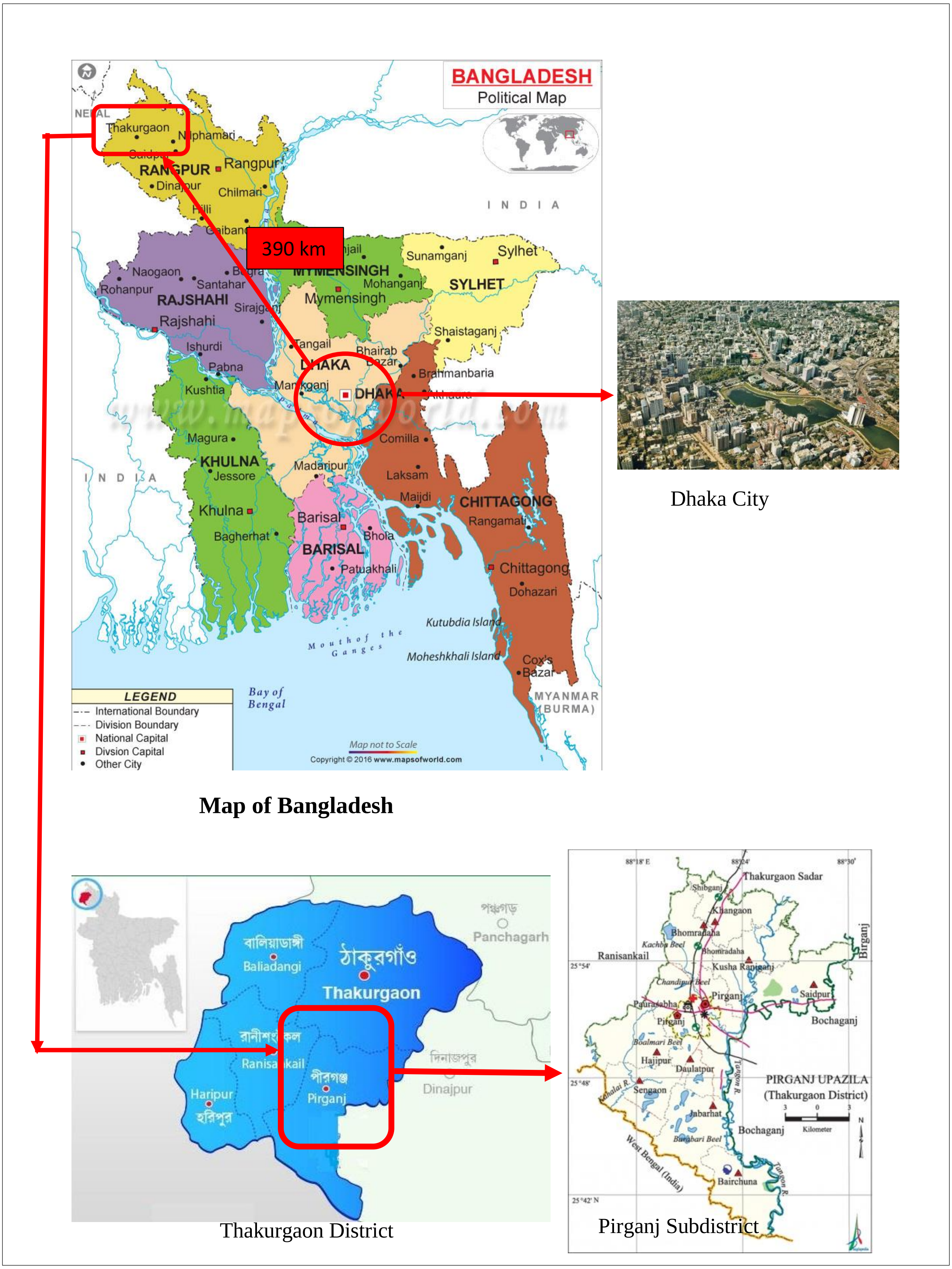

Figure 4. 1: Study area (Dhaka City and Thakurgaon District- Pirganj Subdistrict)

4.3.4 Study population

Two groups were selected;

i. **Rural-to-urban migrants**, who migrated from Pirganj to Dhaka City and had been residing there permanently for at least one year;

ii. **Rural**, participants who have always lived in a rural environment or Pirganj and had a migrant sibling of the same gender.

4.3.4.1 Inclusion criteria

i. Willing to participate

ii. Age ≥18-60 years, both gender

iii. For the migrant group, migration status was attributed only to intra-generation migrants (i.e. first generation) and those who permanently resided in Dhaka for at least one year.

4.3.4.2 Exclusion criteria

i. Chronic medical conditions such as diagnosed cardiac or cancer patients or those who had a disability associated with limited mobility as these conditions may restrict the usual dietary and physical activity of the individuals

ii. Unable to answer a short list of simple questions (sociodemographic information such as name, address, or regarding activities and food intake) due to cognitive disability

iii. Migrated for a medical reason

iv. Temporary migrants such as seasonal workers or visitors

v. Pregnant women

4.3.5 Sample size

The required sample size was calculated for the dichotomous variable, physically active or sedentary lifestyle. As the data are paired (siblings), analysis was based on McNemar's Chi-square test. It was anticipated that there would be a strong tendency towards more sedentary behaviour in urban compared to rural areas. Hence, calculation of sample size was set to detect the minimum odds ratio for this effect to 2.0. It was anticipated up to 50% of pairs would have both siblings displaying the same behaviour (active or sedentary) leaving half discordant pairs.

To detect the above mentioned effect size (differences in proportions), 144 pairs were required for a two sided McNemar's test with a probability level set at 5% and achieving 80% power. After allowing for a 20% non-response rate, the sample size was increased to 173 pairs resulting in total 346 participants (173x2= 346). This calculation was done using the sample size calculator G*Power v3.1.9 (357).

As there was no available mean and standard deviation in the literature, we assumed effect size=0.22 for each continuous outcome variable resulting in a similar required sample size each time.

Finally, a total of 176 pairs (176 x 2= 352) of rural-to-urban migrants and their rural siblings, meeting inclusion criteria, were recruited in this study.

4.3.6 Phases of the study

The study was conducted in two phases;

- **First phase was based on the Household (HH) survey:** the survey was conducted in the Pirganj subdistrict. The purpose of this survey was to identify households where at least one person had migrated from the villages. This phase was undertaken in 26 randomly selected mouzas (i.e., villages) of at least 300 households to represent the subdistrict.

- **Second phase or Migrant-sibling study**: in this stage all identified households were selected for data collection on CVD risk factors if any family member or relative was residing in urban areas of Dhaka.

4.3.7 Sampling technique

4.3.7.1 Sampling structure

In Bangladesh there are seven administrative divisions and each division is divided into districts/zilas, and each district into subdistricts/upazilas. Each urban area in a subdistrict is divided into wards, and into mahallas within a ward. A rural area in the subdistrict is divided into Union Parishads (UP) and mouzas within an UP. These divisions allow the areas to be easily separated into rural and urban areas.

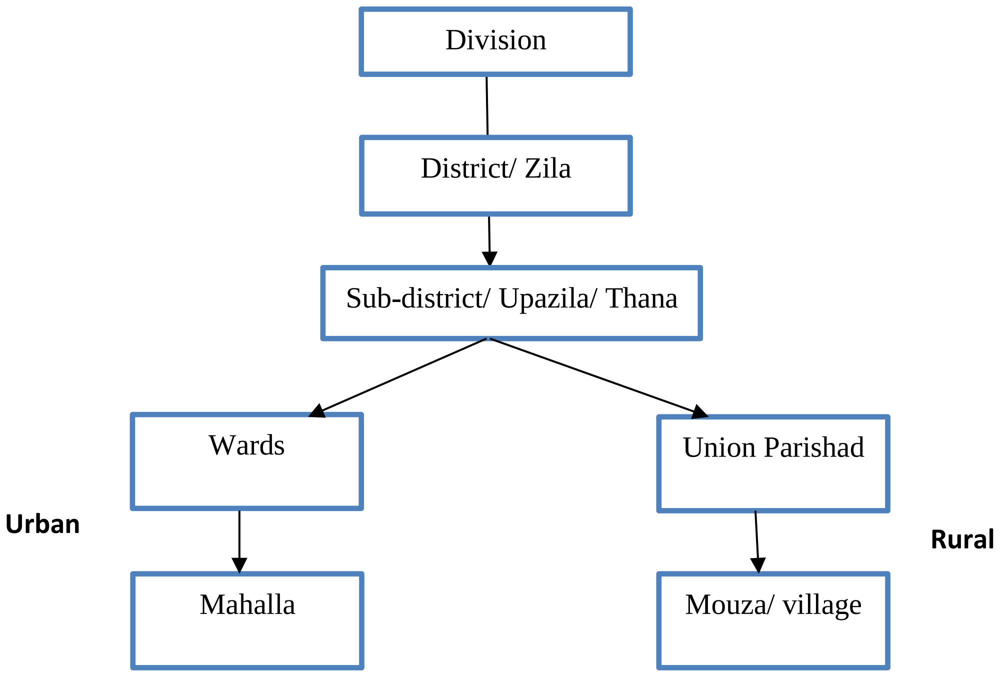

Figure 4. 2: Administrative divisions in Bangladesh

The Pirganj subdistrict of the Thakurgaon district was selected as the source for rural participants. It is situated in the northern part of Bangladesh, approximately 390km from Dhaka city. Thakurgaon district consists of 5 subdistricts and the Pirganj subdistrict is one of them. There are ten unions in Pirganj subdistrict (Table 4.1), covering 215,835 people across 168 mouzas. Mouzas varied substantially in number of households with a median number per mouza of 268, but a range from 188 to 471.

Table 4. 1: Number of Mouza and Household by union in Pirganj Subdistrict

Union code	Union name	Number of mouza in the Union	The median number of HH per Mouza	Total HH in the Union
23	Bairchuna	19	188 (27-1037)	5427
25	Bhomradaha	10	471 (18-1474)	5387
34	Daulatpur	16	261 (23-755)	4093
43	Hajipur	23	234 (12-665)	5801
51	Jabarhat	16	421 (29-827)	6148
60	Khangao	18	211 (45-649)	5019
69	Kusha Raniganj	17	296 (94-868)	5173
77	Pirganj	14	270 (105-614)	4485
86	Saidpur	20	226 (58-578)	5167
94	Sengaon	15	336 (9-772)	5058
Total	**10**	**168**	**268**	**51758**

Source: Bangladesh Population and Housing Census 2011

4.3.7.2 Sampling strategy

For rural group

At first, all 168 mouzas of Pirganj subdistrict were listed for the household survey. Among them 70 mouzas of more than 300 households were identified for random sampling. Considering the average number of adults per household is four (358) and the rate of migration is 11.3 per 1000 people (126), mouzas of at least 300 households covering approximately 1,200 people can yield 11-12 migrants. Thus, for a required sample of 173 pairs we would need to survey 15 mouza of 300 households. However, since we set several inclusion/exclusion criteria (e.g., migrants only to Dhaka, had full sibling [same biological parents] of the same gender and agreed to provide contact information of sibling migrant) we increased the number of selected mouza to 26 of at least 300 households of 10 unions. These mouzas were randomly selected using a random number table to represent the Pirganj subdistrict of Thakurgaon.

All households of the randomly selected mouza were approached to identify rural-to-urban migrants. Coverage of all households in a mouza increased the cost-efficiency of the survey. When the migrant of the identified household was confirmed for participation, then one rural sibling of the same gender of migrant was invited to take part in the study.

For migrant group

Once a rural sibling agreed to the interview and provided the name and contact number of their sibling migrant to Dhaka, we created a list of potential migrant participants, which formed our sampling frame for the migrant study. We contacted each of the migrants to Dhaka from the list, confirmed their eligibility and obtained consent before enrolment. Reasons for non-enrolment were noted.

4.3.8 Data collection approach

To achieve the sample size, we used two phases starting at household level in the rural area for identification, moving to Dhaka for verifying eligibility and to obtain migrant consent and back to the rural area to match the most appropriate sibling. If multiple same-gender siblings were available, the one closest in age was invited. Migrants were asked to attend Bangladesh University of Health Sciences (BUHS) in Dhaka for data collection. Research assistants interviewed rural participants in their homes.

All eligible participants received written material about the aim and study procedure. All participants were given the opportunity to ask questions regarding study procedures before signing the consent. Further, during the study they were able to complain or to withdraw at any time. For illiterate people, investigators read the materials and made sure that participants understood the study properly and could make the decision independently. Participants who agreed to participate in the study were asked to sign the consent form and continued with the assessment.

A team of research assistants and phlebotomist, with previous fieldwork experience of household visits, were trained to enroll participants and to conduct the structured interview. One week of training was provided to the assistants for the selection process, interview and data collection prior to the commencement of the study.

A semi-structured, pre-tested, interviewer administered questionnaire was used for collecting information on socio-demographic, economic, and migration related variables in addition to health-related behaviours including physical activity and diet (through use of validated questionnaires [Chapter 3]), smoking and alcohol consumption. Checklists were used for anthropometry, clinical and biochemical variables.

4.3.9 Variable list

I. **Main exposure variable**

- Rural-to-urban migration

II. **Outcome variables**

a. **Dietary intake**

- Energy intake (kcal)
- Macronutrient intake- carbohydrate, total fat, saturated fat, monounsaturated fat, polyunsaturated fat, protein (grams and % of energy)
- Food groups- Cereals, pulses, dairy, meat, poultry, eggs, fish, leafy vegetables, starchy roots, vegetables, fruits, snacks, fast foods, sweets, beverages (servings/week)

b. **Physical inactivity**

- Domain (work, transport, leisure) and total physical activity (MET-minutes/week)
- Duration of sitting (minutes/day)
- Physical activity level (high, moderate, low)

c. **Anthropometric measurement**

- Height, weight, waist circumference, hip circumference
- BMI, waist:hip ratio, waist:height ratio
- Skinfold thickness (bicep, tricep, subscapular, suprailiac)

d. **Clinical measurements**

- Blood pressure (systolic, diastolic)

e. Biochemical Parameters

- Fasting Blood Glucose (FBG)
- Lipid Profile (total cholesterol [TC], triglyceride [TG], LDL cholesterol, HDL cholesterol)

f. Mental Health

- Mental health status (likely to be well/ likely to have a mental disorder)

III. Other covariates

a. Socio- demographic variables

- Age
- Gender (male)
- Religion
- Marital status
- Educational status
- House type
- Occupation

b. Socio-economic variables

- Monthly household income
- Monthly household expenditure

c. Family characteristics

- Family type
- Family size

d. Family history of Diseases

- Hypertension
- Diabetes mellitus

- Cardiovascular diseases

e. **Behavioural characteristics**

- Tobacco consumption
- Alcohol intake

IV. Variables related to migration

- Place of birth
- Age at first migration
- Education level at first migration
- Years living in urban area

V. Degree of acculturation

- Language
- Diet (i.e., traditional food items, fast food, eating out etc.)
- Perceived changed in physical activity

4.3.9 Data collection instruments & tools

Questionnaire

A semi-structured, pre-tested, interviewer administered questionnaire was used to collect information (Annexure 4.2). Pre-testing of the questionnaire was performed to gather information about ease of comprehension, time taken for each question, consistency among related variables and acceptability. After reviewing the outcome of pre-testing, changes were incorporated accordingly. The questionnaire were prepared in English and translated in to Bengali language. The interview took around 40 minutes to complete.

There were five parts of the questionnaire;

i. Demographic and socio-economic information: In the first part, information was obtained on socio-demographic, family characteristics, monthly household income & expenditure, house type and household assets.

ii. Migration related variables: Information about place of birth (rural, urban), years living in urban area, age at first migration, education level at first migration, occupation before migration and degree of acculturation. Acculturation was measured by length of years lived in urban environment, language use, dietary and physical activity change after migration.

iii. Dietary intake: Diet was assessed by a validated interviewer-administered food frequency questionnaire (FFQ). The validation procedure is described details in Chapter 3c. The questionnaire asks about the frequency of consumption over the last three months and portion size of commonly consumed food items. Detailed nutrient values for Bangladeshi foods (312) were used to calculate calorie, macro and micro nutrients.

iv. Physical activity: Version 2 of GPAQ (235) in Bengali language was used in this study. Validation of the GPAQ was conducted in urban and rural areas of Bangladesh (276) and is described in detail in Chapter 3a. GPAQ-2 collects information on the "usual/typical" week frequency (days) and duration (minutes/hours) of moderate and vigorous intensity physical activity in three domains: 1) at work; 2) during transport; and 3) at leisure (i.e., recreational activities), and comprises 16 questions in total including one question on sedentary behaviour (243).

v. Information related to disease, behavioural characteristics and mental health: Family history of hypertension, diabetes mellitus and CVDs, current disease status, smoking, alcohol and tobacco consumption were recorded.

The Kessler Psychological Distress Scale (K10) (359) was used to assess the presence of common mental disorders among participants. It is widely used population based tool for screening individuals with poor mental health. The K10 scale involves ten questions, each with a five-level response scale. Thus, the maximum score is 50, indicating severe distress while the minimum score is10, indicating no distress. This score can be categorized into the four levels: likely to be well (10-19), likely to have a mild disorder (20-24), likely to have a moderate disorder (25-29) and likely to have a severe disorder (30-50). However, during analysis we collapsed these four categories into two categories, likely to be well (10-19) and likely to have a mental disorder (≥20), because of the small number of participants in the top two categories.

Checklists

Checklists were used for biochemical tests (fasting blood sugar and lipid profile), clinical variables (SBP, DBP) and anthropometric variables (height, weight, waist circumference, hip circumference, skinfold thickness: bicep, tricep, subscapular and suprailiac).

4.3.10 Data collection technique

i. Face to face interview: Information related to socio-demographic characteristics, migration, diet, physical activity, behaviour related variables, and mental health were recorded using the face to face interview technique. Each participant took approximately 30 minutes to complete the interview session.

ii. Anthropometry measurement: the following measurements were obtained;

Weight: Weight was measured using an electronic digital LCD weighing machine. Participants were requested to remove their shoes and extra weight and to wear light clothing. Then they were advised to stand on the weighing scale motionless and with weight distributed equally on both legs.

Height: Height of the participants was measured using a height measuring tape. During height measurement some precautions were taken including; participants stood straight on a plain surface with their back touching the wall surface behind, the head was positioned straight, feet together, knees straight, and heels, buttocks and shoulder blades in contact with the surface of the wall, shoes were taken off and arms were by the sides.

Waist circumference: Participants were asked to stand straight with relaxed abdomen, arms by the sides, feet together and with their weight equally distributed. Waist circumference was taken by placing a measuring tape horizontally midway between the lowest rib margin and the iliac crest in the mid axillary line to measure waist circumference to nearest centimetre. Those collecting the data made sure that the tape didn't compress the participants' skin and was kept parallel to the floor.

Hip circumference: Hip circumference was measured by measuring tape at widest part of the buttocks or hip. Participants stood straight with their weight evenly distributed on both feet and legs slightly parted, making sure not to tense the buttock muscles.

Skinfold thickness: Skinfold thickness (SFTs) was measured using Harpenden

Skinfold Calipers (BATY International Limited, United Kingdom) to the closest 0.2 mm on to the right side of the body. Measurements were taken at the triceps, biceps, subscapular and suprailiac sites. For the triceps, the midpoint of the back of the upper arm between the tips of the olecranon and acromial processes was determined by measuring with the arm flexed at 90º. With the arm hanging freely at the side, the calipers was applied vertically above the olecranon at the marked level. Over the biceps, the SFT was measured at the same level as the triceps, with the arm hanging freely and the palm facing outwards. At the subscapular site, the SFT was picked up just below the inferior angle of the scapular at 45º to the vertical along the natural cleavage lines of the skin. The suprailiac SFT was measured above the iliac crest, just posterior to the midaxillary line and parallel to the cleavages of the lines of the skin, with the arm lightly held forward.

iii. Blood pressure measurement: Blood pressure was measured in a sitting position, with calf at the level of the heart using a sphygmomanometer. After 5 minutes of rest a second reading was taken. The first sound denoted the systolic blood pressure and the disappearance of sound was taken as diastolic blood pressure. If the difference between the two readings was more than 5 mm of Hg for SBP and DBP, a third reading was taken. The mean of the three readings was then considered as the final blood pressure of the participant for data analysis.

iv. Collection of blood samples for biochemical measures: The venous blood was drawn by a trained phlebotomist after at least eight hours of overnight fasting. Five millilitres of blood was taken out for fasting glucose and lipid profile. After that, participants were given 75 grams of glucose in 250 ml of water to drink. Another three millilitres of blood was collected after two hours for 2-h post-oral glucose tolerance test (OGTT). It was ensured that the participant was not doing any vigorous physical activity or taking any food in this time period.

For urban participants the blood sample was collected on the day of interview at the BUHS hospital. Rural participants were invited to attend a blood collection camp for blood sample collection. Five blood collection camps were conducted in Pirganj subdistrict for rural participants. Camps were conducted at Lohagora College, Hajipur Union Parishad, Boirchuna Union Parishad, Kosharaniganj Unioin Parishad and Thakurgaon Shasthoseba Hospital (TSH). Rural participants were given a token following completion of the questionnaire. This listed the name of the participant, their age, study identification number, name of their village, and the scheduled time, date and location for their blood sample collection. They also received verbal instructions. Conveyance allowance was reimbursed to all rural and urban participants for attending at the BUHS hospital and camp.

After 30 minutes, blood samples were centrifuged for 10 minutes at 3000 rpm to obtain serum. Tests of all samples were performed at the BUHS laboratory. Samples from rural participants were transferred with Ethylenediaminetetraacetic acid (EDTA) to the core laboratory at BUHS in a box containing dry ice to maintain a suitable temperature. All samples were preserved in a freezer (-70 C) until the laboratory assays were carried out.

Serum glucose was measured by the glucose-oxidase method and the serum lipid profile [total cholesterol (TC), triglyceride (TG), and high density lipoprotein cholesterol (HDL-c)] was measured by the enzymatic-colorimetric method using a conventional automated analyser (Dimension® clinical chemistry system, Siemens Healthcare Diagnostics Inc. USA). The LDL-Cholesterol level in serum was calculated using the following formula;

LDL-cholesterol= Total cholesterol - [1/5(Triglycerides) +HDL cholesterol].

4.3.11 Operational Definitions of CVD outcome measures

Table 4. 2: Study variables, instruments and data collection mode, data manipulation and operational definitions

Study Variables	Instruments	Mode of data collection	Data manipulation	Operational definition
Dietary intake	Food Frequency Questionnaire – validated, (Mumu et al, 2018) asking about the past three months frequency and portion size of commonly consumed food items	Face to face interview	Detailed nutrient values for Bangladeshi foods (312) were used to calculate macro and micro nutrients	• Energy consumption in kilocalories (Kcal) • Macronutrients consumption in grams and (%) of each nutrient from total kcal • Foods were classified into 15 food groups • Serving size was expressed as servings/week • Inadequate fruits and vegetable intake was defined as <5 serving/day (360).
Physical activity	Global Physical Activity Questionnaire (GPAQ V2) (235) validated by Mumu et al. (276) for the study population. GPAQ asks about the usual/typical week frequency (days) and duration (minutes/hours) of moderate and vigorous intensity activities at work, during transport and at leisure. 15 questions in total.	Face to face interview	Energy expenditures: Metabolic Equivalent Values (METs) were assigned to moderate intensity (4 METs) and vigorous-intensity (8 METs) and multiplied by frequency and duration of session to get MET-minutes value per week for each domain and by intensity level across all domains.	• Energy expended at work, travel and leisure • Physical activity level (high, moderate, low) was categorised according to the Global Physical Activity Questionnaire (GPAQ) scoring protocol (Annexure 4.3) (243).
Sedentary time	One question from GPAQ asking about time spent sitting/lying down. Additional question asking about time spent watching TV.	Face to face interview		Expressed in minutes/day
Smoking and smokeless tobacco use (SLT)	Smoking includes cigarette, bidi, cigar, and pipe. Smokeless tobacco includes chewing tobacco (*zarda, gul, sada pata), betel quid, pan-masala*, snuff *(nassi), khaini*	Face to face interview		Smoker or smokeless tobacco user was defined as smoked or used smokeless tobacco currently or within the last 3 month or occasionally
Alcohol intake	Alcohol intake includes local alcohol, beer, wine, spirit etc	Face to face interview		Ever intake of alcohol was defined as who had ever having drunk alcohol
Mental health	Kessler 10 Questionnaire consisted of 10 questions	Face to face interview		Probable case of mental health disorder was defined if Kessler 10 score was ≥20 (359)

Outcome Variables	Instruments	Mode of data collection	Data manipulation	Operational definition
Body Mass Index (BMI)	Weight was measured by weight machine and height was measured by measuring tape	Observation	BMI= Weight (Kg)/ Height (m^2)	Asian BMI criteria were used to categorise and define underweight (< 18·5 kg/m^2), normal (18.5-23.0 kg/m^2), overweight (23-27.5kg/m^2), and obese (> 27.5 kg/m^2) (169)
Abdominal obesity	Waist circumference was measured by measuring tape	Observation		Abdominal obesity was diagnosed when waist circumference was >90 cm in men using the WHO definition (361)
Dyslipidaemia	Blood sample collection for lipid profile which included TG, TC, HDL, LDL	Laboratory biochemical analysis		Dyslipidaemia was defined as high total serum cholesterol (≥200 mg/dl), high triglycerides (≥150 mg/dl), high LDL cholesterol (≥130 mg/dl) or low HDL cholesterol (<40 mg/dl in men)
Hypertension	Sphygmomanometer	Observation		Hypertension was defined as a systolic blood pressure ≥ 140 mmHg or a diastolic blood pressure ≥ 90 mmHg or current treatment with antihypertensive medication (164).
Diabetes	Blood sample collection for FBG and OGTT	Laboratory biochemical analysis		Diabetes was defined if FBG ≥7.0 mmol/L or OGTT ≥11.1 mmol/L or self-reported diabetes medication use (170).
Income groups	Questions asked about monthly and yearly family income in Bangladeshi Taka (BDT)	Face to face interview	Converted BDT to US$ 1US$=80 BDT	Socioeconomic classifications were made according to the 2006 per capita Gross National Income (GNI) and according to World Bank (WB) calculations. The groups were: low-income, US$ ≤ 905 or Bangladeshi Taka; BDT ≤ 5360; lower-middle-income, US$ (906–3595) or BDT (5361–21270); upper-middle-income, US$ (3596–11115) or BDT (21271–65761); and high-income, US$ ≥11116 or BDT ≥65762 (320).
Acculturation	Questions asked about years lived in urban area, language use at home and with friends, music, current dietary practice compared to before migration and perception of change in physical activity from before and after migration	Face to face interview		Length of years lived in urban environment were classified into tertiles. Language use was categorised as; local dialect, both dialects, standard dialect. Dietary practice was categorised as more often, same, less often and never. Physical activity perception was categorised as much more, more, same, less or very less active.

4.3.10 Data analysis

The data were processed and then imported into and analysed SPSS version 23. After data entry, range and consistency were checked. In this chapter, analysis was conducted on men only and excluded women as only 12 women participated in the study. The analyses include descriptive statistics of the selected variables. Box and whisker plots were used to detect extreme outliers and if the value was more than 3 IQR above the third quartile or below the first quartile, the outlier was removed from the analysis. Paired t-tests, Wilcoxon signed-rank tests and McNemar χ^2 tests were performed to compare between group differences in paired continuous normal, non-normal and categorical outcome variables, respectively.

In the multivariate model, a random effect of pair was included which made two siblings similar (within-pair correlation) and at the same time different to individuals from other sibling pairs (between-pair variation). Comparisons were made between rural-to-urban migrants and rural siblings using linear mixed effects models for continuous outcomes and generalised linear mixed effect models (GLMM) for the binary outcomes, with a pair-specific random effect. However, random effect was excluded for the diabetes and mental health disorder outcomes as no measurable variation in risk of these two outcomes was found between the sibling pairs, and the random intercept was 0.

Four core models were developed as follows. Model 1 adjusted for age, marital status, education, occupation, house type, and monthly family income. Model 2 added energy intake and physical activity. Model 3 added BMI and model 4 added smoking, tobacco intake, family history, and mental disorder. All p values presented were two tailed. The statistical tests were considered significant at a level of 5 % (0.05). Data were presented in tables and graphs.

4.4 Results

4.4.1 Household survey and Response rate

The Household survey was performed to identify rural-to-urban migrants. Twenty-six villages of 10 unions of Pirganj subdistrict were randomly selected and a total of 13,736 household were visited to identify rural-to-urban migrants. Compared to the Bangladesh Census 2011, the coverage of this household survey was 98.7%. Detailed household information was taken from the family head. If there was any migrant in the household, detailed migration related information such as duration, reason, place etc. was obtained. A total of 496 migrants were identified and among them 452 migrated to Dhaka city.

Table 4. 3: Household Survey at Pirganj Subdistrict

Union No. and Name	Name of village/mouza	No. of Household	Total migrant identifies	Migrants to Dhaka	Data collected
No. 1 Bhomradaha	Bhomradaha	1709	58	57	33
	Sinuya	320	15	15	6
	Khamar senua	761	14	14	3
No. 2 Kusha Raniganj	Bazardeha	336	13	12	1
	Kachan Dumuria	343	23	19	9
	Garura	399	9	7	1
	Akasil	359	13	13	2
No. 3 Khangaon	Chandpur	647	10	10	2
	Khangaon	684	10	10	0
	Shimulbari	345	9	9	7
No. 5 Saidpur	Thumnia	538	10	10	6
No. 6 Pirganj	Begungaon	446	14	13	3
No. 7 Hajipur	Bhebra	416	18	17	8
	Singarol	390	24	21	8
	Karna	481	70	62	21
	Sindagar	302	5	4	0
	Satia	567	39	33	4
	Ekannapur	454	12	10	4
No. 8 Daulatpur	Banshgara	413	5	5	4
No. 9 Sengaon	Nohali	416	11	10	7
No. 10 Jabarhat	Bridhigaon	437	10	9	3
	Chandaria	778	22	19	11
No. 11 Bairchuna	Dokshin Noapara	378	6	5	1
	Ajlabad	465	25	24	14
	Ramna Chandahar	400	8	7	3
	Bairchuna	952	43	37	15
Total=10	**26**	**13736**	**496**	**452**	**176**

4.4.1.1 Response rate

The final sample size was 176 pairs. Of these, only 7% (12/176) were female. Hence further analysis was conducted on men only. Overall, the response rate at completion of the study was 41%. Figure 4.3 details the flow of potential participants at each stage of recruitment using the STROBE guidelines for reporting on observational studies (362).

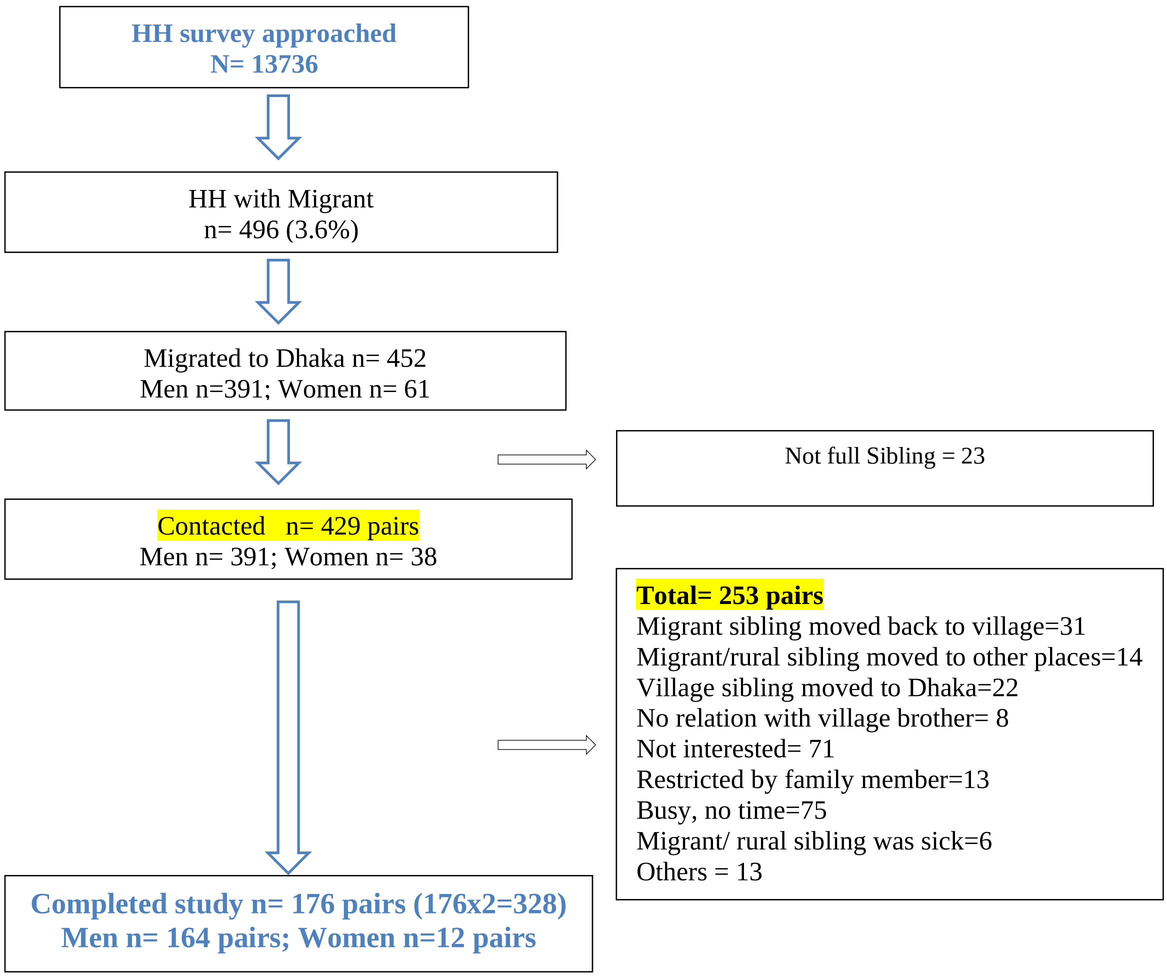

Figure 4. 3: Study participant flowchart

4.4.2 Study population characteristics and migration status

Table 4.4 describes the socio-demographic characteristics of respondents by migration status. A total of 352 participants or 176 pairs were included in the analyses of whom 164 pairs (93%) were men; thus, we have included only men in the analysis.

Compared to migrants, the mean±SD age was higher for rural men (31.87±7.54 vs 33.35±9.33; $p=0.02$). The percentage of those with university level education was significantly higher for rural-to-urban migrants than their rural siblings. Nearly one-third of rural siblings (31.7%) were illiterate to primary level, compared to 14.6% of migrants ($p<.001$). About half of the migrants (47%) were professional workers, and the proportion of manual workers was lower for migrants than their rural counterparts (53% vs 65.9%; $p<0.02$). More than half of the migrants (55%) lived in a brick house whereas only 15% of rural siblings lived in a brick house. Migrants were better off economically compared to rural siblings. Firstly, the total median family income was significantly higher among migrants than their rural siblings. Secondly, most of the rural siblings (86%) were concentrated in the lower-middle income category compared to 63% of migrants falling in this category. More than a third of migrants were classified in the upper middle income or high income category compared to 5% in the rural sibling group.

Table 4. 4: Study population characteristics by migration status

Study Population Characteristics	Rural-to-Urban Migrants	Rural Siblings	p
n (%)			
Age (y), mean (±SD)	31.87 (±7.54)	33.35 (±9.33)	0.02*
Muslim Religion, n (%)	147 (89.6)	147 (89.6)	1.00†
Marital status, n (%)			
Currently married	119 (72.6)	116 (70.7)	
Never married	45 (27.4)	48 (29.3)	0.76†
Highest Grade of Education, n (%)			
Illiterate to Primary level	24 (14.6)	52 (31.7)	
High school level	111 (67.7)	88 (53.7)	<0.001†
University level	29 (17.7)	24 (14.6)	
Occupation, n (%)			
Manual (farmer, day labour, factory workers etc.)	87 (53.0)	108 (65.9)	0.02†
Others (professional, teacher, clerk, service etc.)	77 (47.0)	56 (34.1)	
House type			
Mud	2 (1.20)	58 (35.4)	
Tin shed	71 (43.3)	81 (49.4)	<0.001†
Brick	91 (55.5)	25 (15.2)	
Total family income, BDT, median (Q1;Q3)	16,250 (12000; 25000)	10,000 (8000; 13000)	<0.001‡
Income group, n (%)			
Low income	1 (0.6)	14 (8.5)	
Lower-middle income	103 (62.8)	141 (86.0)	
Upper-middle income	55 (33.5)	8 (4.9)	<0.001†
High income	5 (3)	1 (0.6)	

BDT= Bangladeshi Taka; 1US$=80 BDT

*Results are expressed as number (%), mean (±SD) and median (Q1;Q3); *Paired t-test was performed for paired continuous, normally distributed variables; †McNemar X^2test was performed for paired categorical variables; ‡Wilcoxon signed-rank test was performed for paired continuous, non-normally distributed variables.*

4.4.3 CVD risk factors and migration status

4.4.3.1 Physical activity

Table 4.5 presents the distribution of physical activity by migration status among men. Rural siblings reported significantly higher total MVPA (median MET-minutes/week: 2340 vs. 800 p=0.04) than urban migrants. The median weekly travel-related moderate physical activity (710 vs 380 MET-minutes, p<0.001) and leisure time MVPA (260 vs 0 MET-minutes, p<0.001) were higher in rural siblings than migrants. Work related MVPA did not differ significantly. In the case of sedentary behaviour, the median duration of sitting was 60 minutes/day higher in migrants than their rural siblings. Migrants were found more inactive than their rural counterparts (42.7% vs 21%; p<0.001) (Table 4.5).

Table 4. 5: Differences in physical activity related energy expenditures for each domain and intensity by participants' migration status (n=164)

Physical Activity	Rural-to-Urban Migrants	Rural Siblings	
GPAQ (MET-minutes/wk)	**Median (Q1; Q3)**	**Median (Q1; Q3)**	**p***
Work			
Vigorous	0 (0; 0)	100 (0; 960)	0.001
Moderate	0 (0; 680)	340 (0; 840)	0.70
Total Work MVPA	0 (0; 1440)	840 (180; 1920)	0.13
Travel	380 (240; 810)	710 (240; 1400)	<0.001
Recreation			
Vigorous	0 (0; 0)	0 (0; 0)	0.68
Moderate	0 (0; 0)	240 (0; 715)	<0.001
Total Recreation MVPA	0 (0; 120)	260 (0; 840)	<0.001
GPAQ Total MVPA	840 (360; 3290)	2340 (810; 4280)	0.04
Duration of Sitting/lying (minutes/day)	180 (120; 240)	120 (120; 180)	0.001
Duration of TV watching (minutes/day)	83 (60; 120)	57 (21; 116)	<0.001
Physical Activity level‡	**n (%) (95% CI)**	**n (%) (95% CI)**	**p†**
Highly active	49 (29.90) (22.89-36.91)	72 (43.90) (36.30- 51.50)	<0.001
Moderately active	45 (27.40) (20.57- 34.23)	57 (34.80) (27.51- 42.09)	
Low active	70 (42.70) (35.13- 50.27)	35 (21.30) (15.03- 27.57)	

*Results are expressed as median (Q1;Q3) and Percentage (95%CI); *Wilcoxon matched pair signed rank test was performed for paired non-normal variables; † McNemar X^2test was performed for paired categorical variables*
‡ Categorized according to GPAQ Guideline

4.4.3.2 Dietary intake

Mean reported energy intake was lower in migrants than rural siblings (2823 kcal vs 3930 kcal, p<0.001) (Table 4.6). The same pattern was seen for fat, saturated fat, mono and poly unsaturated fat, carbohydrate and protein (all p<0.001). Differences between these groups in proportion of energy from macronutrients were small but migrants had a higher proportion of energy from fat, saturated fat and carbohydrate. On the other hand, the proportion of energy from monounsaturated and polyunsaturated fats (p=0.02) were higher in rural siblings than migrants.

Table 4. 6: Differences in total energy intake and the proportion of energy attributed to macronutrient intake by participants' migration status

Migrant	Rural-to-Urban Migrants	Rural Siblings	N	Mean Difference 95% CI	p
Energy (kcal)	2823± 914	3930± 1028	164	-1107 (-1321, -894)	<0.001
Fat (g)	40± 19	53± 23	164	-13 (-17, -9)	<0.001
(% energy)	12.97± 4.71	12.12± 3.61		0.84 (-0.05, 1.73)	0.06
Saturated Fat (g)	12.28±5.99	16.59±7.32	162	-4.32(-5.70, -2.93)	<0.001
(% energy)	3.98±1.55	3.87±1.37		0.11 (-0.19, 0.39)	0.52
Monounsaturated Fat (g)	9.75±4.41	13.72±5.82	162	-3.97 (-4.98, -2.95)	<0.001
(% energy)	3.15±1.14	3.17±0.98		-0.02 (-0.24, 0.19)	0.87
Polyunsaturated Fat (g)	9.45±4.55	13.99±4.99	160	-4.54 (-5.53, -3.56)	<0.001
(% energy)	2.98±1.16	3.24±0.84	157	-0.26 (-0.47, -0.05)	0.02
Protein (g)	106± 39	162± 58	164	-55 (-66, -45)	<0.001
(% energy)	15.10± 2.36	16.29± 2.84		-1.19 (-1.71, -0.66)	<0.001
Carbohydrate (g)	499± 174	683± 178	164	-227 (-270, -185)	<0.001
(% energy)	70.55± 6.05	69.71± 5.45		0.83 (-0.39, 2.06)	0.18

Results are expressed as mean (±SD); Paired t-test was performed

Table 4.7 represents the number of 'servings' consumed per week by food group. Migrants reported higher consumption of red meat (2.15 vs 2.05, p=0.94), eggs (2.7 vs 2.5, p=0.45) and fast food (0.23 vs 0, p<0.001). On the other hand, the median number of servings of leafy vegetables (7.6 vs 2.1, p<0.001), vegetables (19.34 vs 8.45, p<0.001), fish (20.4 vs 7.7, p<0.001), and poultry (3.5 vs 2.4; p<0.001) consumption were significantly higher in the rural sibling group compared to the migrant group. This pattern was also observed for carbohydrate rich food groups including cereals, starchy roots and tubers. For fruit intake, migrants had a lower intake compared to the rural group though differences in proportions were not significant (15.8 vs 17.9, p=0.48).

Table 4. 7: Differences in frequency of food group consumption by participants' migration status (n=164)

Foods and food groups, servings/week	Rural-to-Urban Migrants Median (Q1; Q3)	Rural Siblings Median (Q1; Q3)	p
Cereals and their products	41.94 (30.03; 46.64)	54.78 (46.93; 70.58)	<0.001
Pulses, legumes	10.08 (5.33; 17.81)	11.48 (5.56; 18.74)	0.32
Milk and its products	1.78 (0.64; 3.98)	2.00 (0.82; 4.88)	0.11
Meat	2.15 (0.80; 4.96)	2.05 (0.87; 4.39)	0.94
Poultry	2.39 (1.23; 4.38)	3.50 (1.87; 7.00)	<0.001
Eggs	2.70 (1.47; 4.00)	2.47 (2.00; 3.13)	0.45
Fish	7.72 (4.55; 12.90)	20.42 (11.93; 31.76)	<0.001
Leafy vegetables	2.12 (1.18; 3.93)	7.55 (4.70; 11.60)	<0.001
Starchy roots, tubers	8.08 (5.28; 15.55)	20.70 (11.26; 31.73)	<0.001
Vegetables	8.45 (5.69; 14.00)	19.34 (12.64; 27.77)	<0.001
Fruits	15.79 (6.73; 31.44)	17.86 (3.37; 36.62)	0.48
Snacks	8.11 (3.60; 14.35)	10.07 (7.11; 14.93)	0.003
Fast foods	0.23 (0; 0.91)	0 (0; 0)	<0.001
Sweets	4.07 (2.04; 6.56)	4.58 (2.61; 7.59)	0.09
Beverages	7.08 (2.24; 14.00)	7.23 (2.47; 14.12)	0.80

Results are expressed as median (Q1; Q3); Wilcoxon matched pair signed rank test was performed

4.4.3.3 Smoking, alcohol intake and mental health disorders

A higher prevalence of cigarette smoking was found among migrant men (51% vs 40.9%; p=0.05) whereas bidi smoking was higher among rural siblings than migrants (17.1% vs 26.2%; p=0.03). A low prevalence of alcohol intake was found in both groups. Migrants were twice as likely to be classified as 'probable cases of mental disorder' than their rural counterparts (22.6% vs 10.4%, p<0.01). (Table 4.8)

Table 4. 8: Smoking, alcohol intake and mental health disorders among the study participants by migration status

Behavioural risk factors	**Rural-to-Urban Migrants n (%)**	**Rural Siblings n (%)**	**p**
Smoking and alcohol intake			
Ever smoked, n (%)			
Never	80 (48.8)	97 (59.1)	0.057
Ever smoked	84 (51.2)	67 (40.9)	
Ever used smokeless tobacco, n (%)			
Never	136 (82.9)	121 (73.8)	0.036
Ever used smokeless tobacco	28 (17.1)	43 (26.2)	
Ever had alcohol, n (%)			
Never	158 (96.3)	163 (99.4)	-
Ever had alcohol	6 (3.7)	1 (0.6)	
Mental disorder			
Likely to be well (score 10-19)	127 (77.4)	147 (89.6)	0.006
Likely to have a mental disorder (score ≥20)	37 (22.6)	17 (10.4)	

Results are expressed as number (%); McNemar X^2test was performed

4.4.3.4 Metabolic risk factors

Comparisons of metabolic risk factors between migrants and rural groups are shown in Table 4.9. The magnitude of the differences in anthropometric risk factors was substantially higher in the migrant group when compared to the rural group. Mean BMI (22.97 vs 21.99; p=0.001) and waist circumference (83 vs 79; p<0.001) were significantly higher in migrants than rural siblings. In the case of the skinfolds, migrants were 3-6 mm higher compared to the rural group (all p<0.001).

Fasting blood glucose and 2-hr OGTT levels were lower in the rural group compared to their migrant siblings (p<0.001). For lipid measures, migrants were significantly higher for TC (mean 214 vs 194; p=0.001) and LDL (mean 139 vs 114; p<0.001). However, differences between groups in TG were non-significant. On the other hand, the mean HDL level was higher in rural siblings than migrants (43.2 vs 40.5; p=0.001). Although the migrant group had significantly higher levels than the rural group for most risk factors, one exception was blood pressure, which showed a higher mean of SBP and DBP among rural siblings than migrants.

Table 4. 9: Differences in metabolic CVD risk factors between migrants and rural siblings

Metabolic Risk Factors	Rural-to-Urban Migrants Mean (±SD)	Rural Siblings Mean (±SD)	n	Mean Difference 95% CI	p
Anthropometry					
Height, m	1.66 (±0.06)	1.65 (±0.06)	163	0.01 (-0.003, 0.017)	0.16
Weight, kg	62.99 (±10.50)	59.78 (±9.22)	164	3.21 (1.56, 4.87)	<0.001
BMI, kg/m^2	22.97 (±3.43)	21.99 (±3.19)	163	0.98 (0.39, 1.56)	0.001
Waist circumference, cm	83.19 (±11.88)	79.07 (±11.26)	163	4.12 (1.95, 6.29)	<0.001
Waist: Hip ratio	0.92 (±0.06)	0.90 (±0.06)	159	0.02 (0.01, 0.03)	0.002
Waist: Height ratio	0.50 (±0.07)	0.48 (±0.06)	161	0.02 (0.01, 0.04)	0.001
Skinfold thickness					
Bicep, mm	11.63 (±8.01)	5.45 (±2.14)	132	6.19 (4.79, 7.59)	<0.001
Tricep, mm	15.24 (±6.12)	11.10 (±4.71)	132	4.14 (2.83, 5.45)	<0.001
Subscapular, mm	19.28 (±6.21)	14.88 (±4.90)	132	4.39 (3.22, 5.57)	<0.001
Suprailiac, mm	22.04 (±8.34)	18.04 (±8.73)	132	3.99 (2.19, 5.79)	<0.001
Blood Pressure					
Systolic, mmHg	108.90 (±11.51)	113.40 (±13.16)	164	-4.46 (-7.05, -1.87)	0.001
Diastolic, mmHg	72.91 (±9.79)	75.28 (±9.13)	163	-2.36 (-4.16, -0.57)	0.01
Blood Glucose					
Fasting Blood Glucose (FBG), mmol/l	5.63 (±1.34)	5.00 (±0.67)	127	0.63 (0.38, 0.88)	<0.001
2-hr OGTT, mmol/l	7.78 (±2.17)	6.57 (±1.15)	127	1.20 (0.80, 1.61)	<0.001
Lipid Profile					
TG, mgm/dl	175.94 (±117.43)	164.88 (±65.49)	131	11.06 (-11.60, 33.73)	0.34
TC, mgm/dl	214.39 (±69.54)	194.23 (±34.57)	138	20.15 (8.60, 31.72)	0.001
HDL, mgm/dl	40.54 (±8.94)	43.22 (±4.21)	136	-2.68 (-4.31, -1.06)	0.001
LDL, mgm/dl	138.60 (±58.39)	114.00 (±36.53)	138	24.56 (14.85, 34.26)	<0.001

BMI= Body Mass Index, TG= Triglyceride, TC= Total Cholesterol, HDL= High-density lipoprotein, LDL= Low-density lipoprotein, OGTT= Oral Glucose Tolerance Test
Results are expressed as mean (±SD); Paired t-test was performed

4.4.3.5 Proportion of CVD risk factors among migrants and non-migrants

For most of the risk factors, migrants had significantly higher levels than the rural group except smokeless tobacco consumption. Although mean SBP and DBP were higher in rural siblings than migrants (Table 4.9), this pattern was reversed when hypertension was the outcome after adding the current treatment with antihypertensive drug. No significant difference was observed for waist: hip ratio, hypertension and TG between migrant and rural siblings (Figure 4.4).

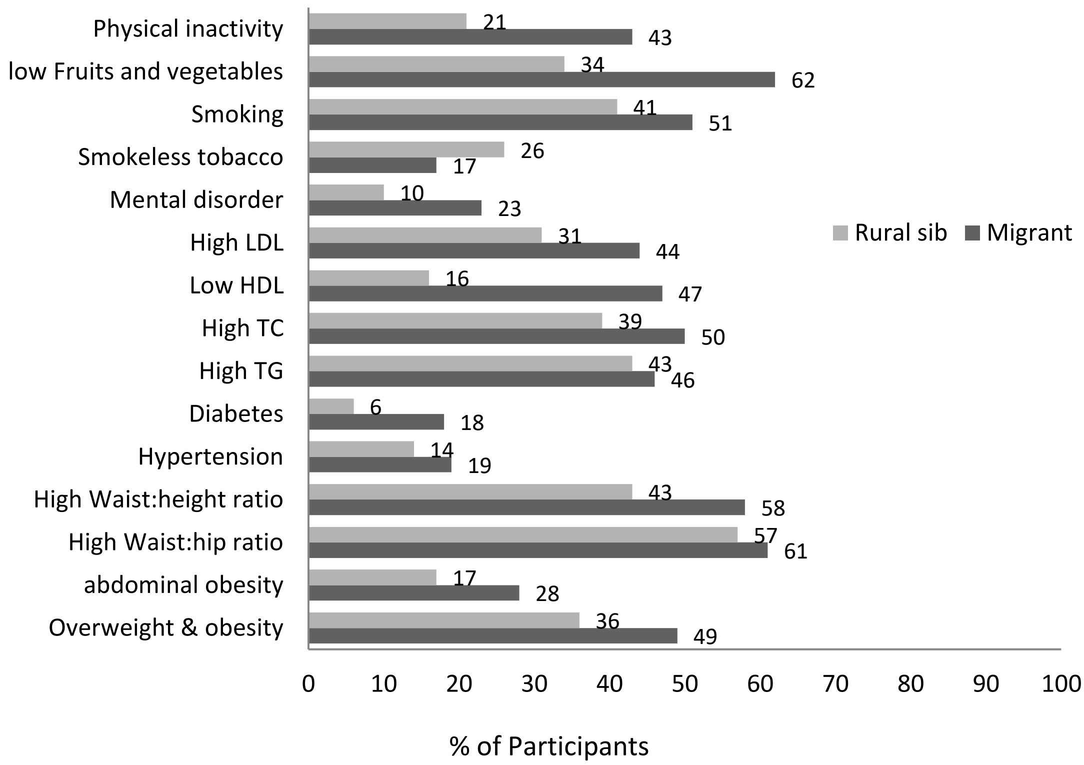

Figure 4. 4: Proportion of CVD risk factors by study groups

4.4.3.6 Independent association between migration status with CVD risk factors

Table 4.10 shows the adjusted association of migration status with CVD risk factors. For most risk factors the migrant group had higher levels than the rural group. Migrant group watched television on average 20 minutes more per day (95% CI 6.17–35.08 min/day) than the rural sibling group. The poly unsaturated fatty acid (PUFA) intake, fruit and vegetable and fish intake of the migrants were -5.31 gm/day (-6.91; -3.70), -21.64 serving/week (-28.20; -15.09), -14.10 serving/week (-18.32; -9.87) lower than that of the rural siblings. With the exception of systolic and diastolic blood pressure, migrants had a consistently greater number of adverse measures than their rural siblings; this includes BMI, skinfold thickness, HDL, TC/HDL ratio, fasting blood glucose and 2-hr OGTT after adjusting for all confounders. Systolic and diastolic blood pressure were lower in migrants than the rural siblings.

Table 4. 10: β coefficients (95% CI) of continuous cardiovascular risk factors by migration status

Variables	Rural siblings	Rural-to-Urban Migrants
		β coefficients (95% CI)
MVPA MET-min/week		
Model 1	Ref	-31.14 (-187.96; 6.50)
TV watching, min/day		
Model 1	Ref	20.63 (6.17; 35.08)
Energy intake, Kcal/day		
Model 1	Ref	-1109 (-1367; -851)
Fat intake, gm/day		
Model 1	Ref	-16.49 (-21.82; -11.17)
PUFA intake, gm/day		
Model 1	Ref	-5.31 (-6.91; -3.70)
Fruit & veg intake, serving/week		
Model 1	Ref	-21.64 (-28.20; -15.09)
Fish intake, serving/week		
Model 1	Ref	-14.10 (-18.32; -9.87)
BMI, kg/m^2		
Model 1	Ref	0.84 (0.02; 1.67)
Model 2	Ref	1.24 (0.37; 2.13)
Waist circumference, cm		
Model 1	Ref	2.80 (0.02; 5.59)
Model 2	Ref	2.91 (-0.91; 5.92)
All Skinfolds, mm		
Model 1	Ref	14.23 (9.13; 19.33)
Model 2	Ref	17.22 (11.49; 22.95)
TG, mgm/dl		
Model 1	Ref	7.67 (-17.95; 33.29)
Model 2	Ref	12.46 (-16.47; 41.40)
Model 3	Ref	5.04 (-23.39; 33.47)
TC, mgm/dl		
Model 1	Ref	11.43 (-2.34; 25.91)
Model 2	Ref	9.43 (-6.20; 25.06)
Model 3	Ref	4.21 (-10.87; 19.29)
HDL, mgm/dl		
Model 1	Ref	-2.81 (-4.79; -0.84)
Model 2	Ref	-2.89 (-5.11; -0.66)
Model 3	Ref	-2.67 (-4.92; -0.43)
LDL, mgm/dl		
Model 1	Ref	16.42 (4.47; 28.38)
Model 2	Ref	13.87 (0.27; 27.48)
Model 3	Ref	9.92 (-3.36; 23.20)

Table 4.10 (continue)

Variables	Rural siblings	Rural-to-Urban Migrants β coefficients (95% CI)
TC/HDL ratio		
Model 1	Ref	0.74 (0.33; 1.15)
Model 2	Ref	0.71 (0.25; 1.18)
Model 3	Ref	0.54 (0.11; 1.0)
Fasting Blood Glucose (FBG), mmol/l		
Model 1	Ref	0.56 (0.27; 0.85)
Model 2	Ref	0.59 (0.25; 0.92)
Model 3	Ref	0.50 (0.16; 0.83)
Model 4	Ref	0.54 (0.21; 0.87)
2-hr OGTT, mmol/l		
Model 1	Ref	1.15 (0.69; 1.63)
Model 2	Ref	1.08 (0.54; 1.61)
Model 3	Ref	0.90 (0.37; 1.43)
Model 4	Ref	0.92 (0.39; 1.46)
Systolic, mmHg		
Model 1	Ref	-4.70 (-7.89; -1.51)
Model 2	Ref	-3.99 (-7.52; -0.47)
Model 3	Ref	-5.41 (-8.75; -2.08)
Model 4	Ref	-5.01 (-8.40; -1.63)
Diastolic, mmHg		
Model 1	Ref	-2.86 (-5.27; -0.45)
Model 2	Ref	-1.97 (-4.65; 0.71)
Model 3	Ref	-2.98 (-5.54; -0.42)
Model 4	Ref	-2.80 (-5.40; 0.21)

BMI= Body Mass Index, TG= Triglyceride, TC= Total Cholesterol, HDL= High-density lipoprotein, LDL= Low-density lipoprotein, OGTT= Oral Glucose Tolerance Test
Linear Mixed Effect Model was performed with a random effect of sibling-pair
Model 1: Adjusted for Age, Marital status, Education, Occupation, House type, Monthly family income
Model 2: as model 1 + Energy intake, MET-min/week
Model 3: as model 2 + BMI
Model 4: as model 3 + Smoking, Tobacco intake, Family history, and Mental disorder

Table 4.11 presents the adjusted odds ratios for CVD risk factors among migrants compared to rural siblings. Physical inactivity, inadequate intake of fruit and vegetables and possible existence of a mental health disorder were 3.3 (1.73; 6.16), 4.3 (2.32; 7.92) and 2.9 (1.37; 6.27) times higher among migrants than their rural siblings. Furthermore, in the first multivariate model, migrants were 3.92 (95% CI: 2.03; 7.56) times more likely to have low HDL levels and 3.69 (95% CI: 1.46; 9.35) times more likely to be diabetic compared to their rural siblings. However, attenuation was observed for diabetes after adjustment for energy intake, physical activity and BMI suggesting that these lifestyles explain most of the differences in diabetes risk. Although SBP and DBP were higher in rural siblings than migrants (Table 4.10 negative Beta coefficients) , this pattern was reversed when hypertension was the outcome after adding the current treatment with antihypertensive drug (Table 4.10) indicating that migrants had a 50% higher risk of being classified as hypertensive than their rural siblings (AOR=1.5, 95% CI: 0.63-3.83).

Table 4. 11: Adjusted odds ratios (95% CI) for cardiovascular risk factors by migration status

Risk Factors	Rural siblings	Rural-to-Urban Migrants Odds ratios (95% CI)
Physically inactive		
Model 1	Ref	3.26 (1.73; 6.16)
Inadequate fruit & veg intake (≤5 serving/day)		
Model 1	Ref	4.29 (2.32; 7.92)
Ever smoked		
Model 1	Ref	1.46 (0.84; 2.56)
Smokeless tobacco intake		
Model 1	Ref	0.85 (0.40; 1.77)
Mental health disorder†		
Model 1	Ref	2.94 (1.37; 6.27)
Overweight and obesity		
Model 1	Ref	1.13 (0.62; 2.06)
Model 2	Ref	1.31 (0.66; 2.58)
Abdominal obesity		
Model 1	Ref	1.23 (0.62; 2.42)
Model 2	Ref	1.39 (0.64; 2.99)
High TC		
Model 1	Ref	1.19 (0.66; 2.15)
Model 2	Ref	1.32 (0.58; 2.22)
Model 3	Ref	0.99 (0.49; 1.98)
Low HDL		
Model 1	Ref	3.92 (2.03; 7.56)
Model 2	Ref	3.63 (1.72; 7.66)
Model 3	Ref	3.53 (1.66; 7.49)
High LDL		
Model 1	Ref	1.27 (0.68; 2.40)
Model 2	Ref	1.32 (0.65; 2.72)
Model 3	Ref	1.19 (0.57; 2.51)
Diabetic*†		
Model 1	Ref	3.69 (1.46; 9.35)
Model 2	Ref	3.07 (1.06; 8.86)
Model 3	Ref	2.52 (0.89; 7.15)
Model 4	Ref	2.09 (0.711; 6.17)
Hypertension‡		
Model 1	Ref	1.72 (0.83; 3.56)
Model 2	Ref	1.67 (0.73; 3.84)
Model 3	Ref	1.51 (0.63; 3.57)
Model 4	Ref	1.54 (0.63; 3.83)

** Diabetes defined if FBS ≥7.0 mmol/L or OGTT ≥11.1 mmol/L or self-reported diabetes medication use;*
‡Hypertension defined if systolic blood pressure ≥ 140 mmHg or a diastolic blood pressure ≥ 90 mmHg or current treatment with antihypertensive medication

Generalized Linear Model was performed including a random effect of sibling pairs; †excluding random effect as no variation between sibling pair
Model 1: Adjusted for Age, Marital status, Education, Occupation, House type, Monthly family income
Model 2: as model 1 + Energy intake, Physical activity level
Model 3: as model 2 + BMI
Model 4: as model 3 + Smoking, Tobacco intake, and Mental disorder

4.4.4 Migration indicators

Table 4.12 presents indicators of migration among rural-to-urban migrants. The median (Q1; Q3) duration of stay in the urban area was 9 years (5; 15). The mean age at first migration was 21 years and most of the men (93%) migrated to Dhaka for their livelihood.

Table 4. 12: Characteristics of migration indicators among rural-to-urban migrant

Study Population Characteristics	Migrant
Migration Indicator	
Length of urban stay, (y), median (Q1; Q3)	9 (5; 15)
Age at first migration, (y), mean (±SD)	21± 6.18
Reason for Migration, n (%)	
Work	153 (93)
Study	11 (7)
Occupation before migration	
Same as now	17 (10)
Different	147 (90)

4.4.4.1 Migration related factors: Acculturation

Acculturation was measured using length of urban stay, use of language, current dietary practice compared to before migration and perception of change in physical activity from before to after migration. Participants were asked which dialect they used to communicate with their spouse, children, parents and friends. Nearly all (91%) migrants communicated in the local dialect with their parents but this number decreased to one-third while communicating with their spouse, children and friends. Around 23% and 37% of migrants used the standard dialect of Bengali language to communicate with their spouse or children and friends, respectively. Only 10% listened to the local music of Thakurgaon (their rural origin) and 90% liked other types of music.

When migrants were asked if their dietary habits changed since migrating the city, most of them reported increasing consumption of unhealthy foods e.g., soft drinks (74%), energy drinks (59%), coffee/tea (60%), processed/canned foods (76%), eating out (72%) and red meat (60%). Although nearly half of migrants consumed chips/popcorn (48%) and fast food (42%), 25% and 54% never consumed these foods, respectively. Fruit and vegetables were consumed less often compared to before migration (by 39% and 56%, respectively). Participants prepared their traditional food less often (19.5%) or never (28.7%), compared to before migration. However, 29% reported they prepared traditional food more often.

Participants were asked to provide their perception of physical activity habit compared to before migration. More than half (59%) of the participants indicated that they were more active compared to before immigration whereas 36% believed that they were less active. (Table 4.13)

Table 4. 13: Differences in level of acculturation among rural-to-urban migrants

Acculturation variables	Rural-to-Urban Migrants				
Use of Language, n (%)	**Local dialect**	**Both equally**	**Standard dialect**	**N/A**	
Communicates with					
Couple	60 (36.6)	18 (11.0)	39 (23.8)	47 (28.7)	
Children	44 (26.9)	15 (9.1)	34 (23.1)	67 (40.9)	
Parents	149 (90.9)	3 (1.8)	4 (2.4)	8 (4.9)	
Friends	43 (26.2)	60 (36.6)	61 (37.2)	0 (0)	
Favourite music					
Local music	16 (9.8)				
Other	148 (90.2)				
Dietary Practice, n (%)	**More often**	**Same**	**Less often**	**Never**	
Current Dietary habit compared to before migration					
Soda/ soft drinks	121 (73.8)	22 (13.4)	16 (9.8)	5 (3.0)	
Energy drinks	97 (59.1)	13 (7.9)	8 (4.9)	46 (28.0)	
Coffee/tea	98 (59.8)	24 (14.6)	29 (17.7)	13 (7.9)	
Plain water	98 (59.8)	42 (25.6)	24 (14.6)	0 (0)	
Fast food	69 (42.1)	4 (2.4)	2 (1.2)	89 (54.3)	
Oily local foods	93 (56.7)	19 (11.6)	41 (25.0)	11 (6.7)	
Chips/popcorn	78 (47.6)	13 (7.9)	32 (19.5)	41 (25.0)	
Processed or canned foods	124 (75.6)	3 (1.8)	2 (1.2)	35 (21.3)	
Eating out	118 (72.0)	5 (3.0)	16 (9.8)	25 (15.2)	
Butter/cheese/ mayonnaise/ ghee	26 (15.9)	3 (1.8)	33 (20.1)	102 (62.2)	
Fruits	92 (56.1)	8 (4.9)	64 (39.0)	0 (0)	
Vegetables	61 (37.2)	12 (7.3)	91 (55.5)	0 (0)	
Beef/mutton	99 (60.4)	13 (7.9)	50 (30.5)	2 (1.2)	
Chicken	134 (81.7)	7 (4.3)	22 (13.4)	1 (0.6)	
Fish	115 (70.1)	14 (8.5)	35 (21.3)	0 (0)	
Taking vitamin supplement	65 (39.6)	5 (3.0)	10 (6.1)	84 (51.2)	
Preparation of typical dishes of origin	48 (29.3)	37 (22.6)	32 (19.5)	47 (28.7)	
Perception of Physical Activity, n (%)	**much more active**	**more active**	**same**	**less active**	**much less active**
Current physical activity habit compared to before migration	41 (25.0)	57 (34.8)	7 (4.3)	47 (28.7)	12 (7.3)

Results are expressed as number (%)

Table 4.14 shows exposure to urban life years associated with CVD risk factors, unadjusted and adjusted for a range of confounders. Urban life years were categorised into tertiles and a significant trend for higher levels of risk factors, except tobacco and hypertension, from rural non-migrants to migrants was seen for the unadjusted OR. After adjusting, the risk of physical inactivity, inadequate fruit and vegetable intake, a mental health disorder and low HDL were significantly higher in migrants than in rural siblings and tended to be higher for each increasing tertile of urban life exposure. However, diabetes was 5.5 times higher in migrants than rural siblings in the first tertile of urban life exposure, but no clear pattern of higher diabetes risk was found in the following tertiles.

Table 4.15 presents the effect size of CVD risk factors for rural siblings and migrants by time spent in an urban environment in decades. Physical inactivity, and low intake of fruit and vegetables were more prevalent in migrants than rural non-migrants and the risk increased after the first decade. The risk of low HDL increased from OR 3.7 to 4.4 after the migrant spent a decade in the urban area. However, mental health disorder and diabetes prevalence seem to decrease after a decade, though the ORs were higher in migrants than rural non-migrants.

Table 4. 14: CVDs Risk Factors by tertiles of Urban Life-Years

Risk Factors	0 urban life years	1-6 urban life years	7-12 urban life years	>12 urban life years	*p* for Trend
Unadjusted OR (95% CI)					
Physical inactivity	ref	2.35 (1.24; 4.48)	2.58 (1.32; 5.05)	3.42 (1.78; 6.57)	<0.001
Inadequate fruit & veg intake (≤5 serving/day)	ref	5.18 (2.68; 10.01)	2.17 (1.15; 4.11)	2.60 (1.39; 4.87)	0.001
Ever smoked	ref	1.31 (0.72; 2.38)	1.01 (0.54; 1.92)	2.67 (1.41; 5.06)	0.012
Smokeless tobacco intake	ref	0.44 (0.19; 1.01)	0.69 (0.32; 1.49)	0.64 (0.30; 1.38)	0.17
Mental health disorder	ref	2.21 (0.98; 4.96)	3.95 (1.82; 8.59)	1.73 (0.72; 4.15)	0.02
Overweight and obesity	ref	0.983 (0.53; 1.83)	1.71 (0.91; 3.23)	3.28 (1.72; 6.24)	<0.001
Abdominal obesity	ref	0.99 (0.45; 2.19)	1.04 (0.46; 2.38)	4.86 (2.48; 9.50)	<0.001
Low HDL	ref	3.25 (1.60; 6.58)	4.41 (2.14; 9.09)	7.62 (3.74; 15.52)	<0.001
Diabetes	ref	3.53 (1.38; 9.07)	1.68 (0.53; 5.28)	4.22 (1.66; 10.72)	0.007
Hypertension	ref	1.73 (0.81; 3.69)	0.98 (0.39; 2.43)	1.57 (0.71; 3.48)	0.376
Adjusted OR (95% CI)					
Physical inactivity	ref	2.85 (1.34; 6.06)	3.59 (1.62; 7.95)	3.63 (1.57; 8.39)	0.001
Inadequate fruit & veg intake (≤5 serving/day)	ref	5.52 (2.64; 11.63)	2.72 (1.30; 5.69)	4.83 (2.13; 10.98)	<0.001
Ever smoked	ref	1.71 (0.85; 3.43)	0.96 (0.46; 1.99)	1.90 (0.87; 4.16)	0.22
Smokeless tobacco intake	ref	1.04 (0.39; 2.79)	0.86 (0.34; 2.15)	0.63 (0.23; 1.68)	0.37
Mental health disorder	ref	2.13 (0.86; 5.27)	4.78 (1.93; 11.88)	2.64 (0.92; 7.60)	0.009
Overweight and obesity	ref	1.03 (0.50; 2.10)	1.09 (0.51; 2.32)	1.22 (0.54; 2.74)	0.64
Abdominal obesity	ref	1.06 (0.44; 2.58)	0.72 (0.28; 1.83)	2.17 (0.93; 5.07)	0.16
Low HDL	ref	2.72 (1.23; 6.02)	4.06 (1.80; 9.16)	6.53 (2.74; 15.59)	<0.001
Diabetes	ref	5.53 (1.81; 16.88)	2.10 (0.57; 7.71)	3.30 (0.97; 11.17)	0.12
Hypertension	ref	2.26 (0.95; 5.40)	1.16 (0.42; 3.18)	1.64 (0.61; 4.44)	0.38

**Non-migrants are in the zero urban life years group. Rest of the groups are categorized in tertiles*
Adjusted for Age, Marital status, Education, Occupation, House type, Monthly family income

Table 4. 15: CVD Risk Factors by Decade of Urban Life-Years

Risk Factors	0 urban life years*	First Decade (1-10 urban life years)	After first decade (>10 urban life years)
Physical inactivity	ref	3.22 (1.64; 6.29)	3.35 (1.53; 7.31)
Inadequate fruit & veg intake (≤5 serving/day)	ref	4.12 (2.20; 7.68)	4.31 (2.04; 9.12)
Ever smoked	ref	1.51 (0.83; 2.76)	1.37 (0.67; 2.80)
Smokeless tobacco intake	ref	0.87 (0.39; 2.00)	0.76 (0.31; 1.87)
Mental health disorder	ref	3.23 (1.48; 7.05)	2.33 (0.88; 6.12)
Overweight and obesity	ref	1.13 (0.60; 2.07)	1.05 (0.50; 2.22)
Abdominal obesity	ref	1.11 (0.53; 2.33)	1.39 (0.62; 3.12)
Low HDL	ref	3.66 (1.82; 7.36)	4.41 (1.97; 9.86)
Diabetes	ref	3.90 (1.38; 10.99)	2.70 (0.82; 8.88)
Hypertension	ref	1.76 (0.81; 3.82)	1.61 (0.64; 34.07)

**Non-migrants are in the zero urban life years group.*
Adjusted for Age, Marital status, Education, Occupation, House type, Monthly family income

4.5 Discussion

We have conducted a sibling-pair comparative study design to investigate the effect of rural-to-urban migration by comparing the CVD risk factors among migrants and their rural siblings of the same origin. We also examined whether migration indicators such as longer duration of urban stay and acculturation would be associated with increased risk. A wide range of cardiovascular risk factors were assessed including physical inactivity, dietary intake, smoking, mental health disorders, anthropometry, blood pressure, lipids, and glycaemic status.

For most of the CVD risk factors, the risk profile of the migrant group was higher than the risk profile of the rural non-migrant siblings; however, this was not observed for SBP and DBP. Migration was found to be associated with an increase in physical inactivity and reduced fruit and vegetable and PUFA intake in migrants, compared with rural siblings, and this likely contributed to the higher levels of BMI, skinfold thickness and lower HDL in migrants. A general trend of higher levels of risk in migrants compared to rural non-migrants was seen with a longer period of stay in the urban area. Separate analyses selecting only migrants showed that their language, dietary habits and physical activity changed after migration due to acculturation.

4.5.1 CVD risk factors by migration status

4.5.1.1 Physical activity

Previous research on physical activity within Bangladesh has focused on specific geographic locations or sub-groups (139, 270, 363), however, it has not attempted to examine differences between migrants and other groups. This study confirms that low levels of physical activity and high sedentarism were more prevalent amongst urban migrants compared to their rural siblings, which supports the causal effect of migration rather than selection by pre-migration risk. The findings are consistent with migrant studies in India, Peru, Guatemala and Tanzania (83, 84, 94, 353).

The rural group, those who always lived in a rural environment, were more physically active than their migrant siblings, mainly related to travel and recreational activities rather than occupation. The odds of being classified at a ‘low active’ level (OR= 3.6) were associated with migration status even after adjusting for sociodemographic variables. A study conducted in Peru found that the physical activity profile of migrants were quite resemble to urban residents and low levels of physical activity were 21 times higher in migrants than lifetime rural group (353). Similar findings were observed in the Indian Migration Study (IMS) where the rural siblings reported one hour more MVPA (per day) compared to rural-to-urban migrants (94). The nationwide STEPS cross-sectional study (139) and one small scale study (270) conducted in rural and urban Bangladesh, revealed that urban adults are more physically inactive (or low active) than rural adults.

Although the vigorous work related physical activity differed between migrant and rural groups, moderate intensity work related physical activity did not. This may be due to the similar proportion of manual workers between rural-to-urban migrants (53%) and their rural siblings (66%). In contrast, a cross-sectional study in Bangladesh comparing rural and urban populations showed that the contribution of work related MVPA as a proportion of total MVPA hugely differed between urban (40%) and rural groups (77%) (270). The results of the current study showed that the main difference in total activities between migrants and rural siblings were due to travel and leisure time activities. This indicates that although the work pattern among migrants did not change much, their travel and leisure time activities decreased after migration. Poorly planned urbanisation could explain this variation. Absence of cycleways, narrow and broken sidewalks with crowds and seasonal attributes (e.g. hot and humid in summer, rain during monsoon, dusty in winter) may make those who live in Dhaka unwilling to walk and/or cycle for commuting (135, 212, 364). Moreover, availability of three wheeler passenger cart 'rickshaws' provides less inducement for urban residents to walk even a short distance. The migration study conducted in India showed that whereas 68% of rural dwellers used bicycles, only 16% of urban dwellers used a bicycle for travelling to work (365). Further, the concept of leisure time physical activity is not familiar in Bangladesh and the low level of leisure time activity in urban areas may be partly due to unfavourable infrastructure and inaccessibility to sports or recreational facilities. A study conducted on university students in Dhaka reported mostly environmental barriers for physical activity participation in Dhaka city such as poor street lighting, poor condition of footpaths, lack of safety, heavy neighbourhood traffic, unclean neighbourhoods and lack of facilities and places such as parks for walking or jogging, sports clubs, fitness centres, and gyms. (366). Dhaka city has green space of 0.052 m^2 per capita which is well below the recommendation of 9 m^2 per capita set by the WHO (367).

Very few migration studies (94, 353) have explored sedentary behaviour among migrants. In this study, duration of sitting was significantly higher in migrants than their rural siblings, and TV watching was 20 minutes/day higher in migrants compared to their rural siblings. This is in line with the Indian Migration Study (IMS) (94). In the IMS, migrant men reported one hour more sedentary behaviour and 30 minutes more television viewing than their rural siblings (per day) (94). The Peru migrant study found sedentary behaviour was predominantly (73%) among the rural-to-urban migrants (353).

4.5.1.2 Dietary intake

An unhealthy diet with low fruit, vegetable and unsaturated fat intake, but high saturated fat and salt intake are likely to be associated with the increased risk of cardiovascular diseases (7). The results from this study indicate that migration from a rural area to a mega city such as Dhaka, can have an impact on migrants' diet, as also documented by other studies (76, 81, 83-85, 93). This analysis found that migration from rural to urban areas was associated with lower PUFA intake and lower consumption of fruit and vegetables, as well as fish. There was also evidence of lower consumption of poultry meat and a higher consumption of fast food in urban migrants than rural siblings. Overall, the calorie and macronutrient (gm) intake was higher in rural individuals though the proportion of energy from each nutrient varied between these two distinctive groups.

In this study, migrants were four times more likely to consume inadequate fruit and vegetables than their rural siblings. The multi-country cross-sectional study also found that the proportion of those with adequate fruit and vegetable consumption was higher in rural siblings than migrants in China, Ghana, India and Mexico in the country level findings. However, when all surveys were pooled the proportion with an adequate intake was similar in rural and urban groups (81). In contrast, the longitudinal study of Tanzania showed that consumption of fresh fruit and vegetables increased over 12 months following migration, though saturated fat intake, red meat and soft drink intake increased significantly (83). The same pattern was observed in the migrant study of India where vegetable, as well as sugar and meat consumption, was higher among migrants than their rural siblings (93). However, our findings are comparable to the Household Income and Expenditure survey (HIES) 2010 where rice, potato and vegetable consumption was found to be higher in rural areas than in urban areas of

Bangladesh (368). In the NCD STEP survey of Bangladesh median per capita consumption of fruit and vegetables was found to be very low (2 servings/day). However, this survey did not indicate any significant differences in fruit and vegetables consumption between rural and urban residents. This could be due to the lack of sensitivity in the instrument being used (135). The most probable reason for low consumption are the higher prices of fruit and vegetables in urban areas (139, 368). In rural areas, people meet their dietary needs by cultivating fruit and seasonal vegetables in their home gardens. However, most rural-to-urban migrants live in rented houses (83% in this study) and there is no opportunity or time to do gardening. From Chapter 3.b, we can see that rural people spent more time gardening than urban individuals (12.9 vs 4.8 MET-min/week). Moreover, local varieties of seasonal fruits are sometimes not considered as good fruit by urban people whereas imported, costly fruits are considered real fruit but these are beyond their budget (139).

Fish is one of the significant sources of PUFA (369). However, fish consumption became lower in those migrating from rural areas to Dhaka. Although fish is an integral part of a traditional Bangladeshi meal, lower consumption might be related to higher price and inadequate supply of fish products in Dhaka. Another study of Bangladesh also found that rural people have higher consumption of fish (158.67 g/capita/day) than that of urban people (118.03 g/capita/day) (370). However, the HIES survey showed the opposite where urban dwellers consumed more fish than rural dwellers (368). In IMS, fish consumption was very low in both migrants and rural siblings and no difference was observed between the groups (93).

Overall calorie intake in this study was higher in rural siblings than the rural-to-urban migrant group. This is in line with the HIES 2010 which reported that the calorie intakes in rural and urban areas were 2344.6 kcal and 2253.2 kcal, respectively (368). Although total energy consumption was higher in rural siblings, their mean BMI was lower (0.98 m/kg2) than in the migrant group. This interesting finding may be due to the higher MVPA MET-min by rural siblings compared to rural-to-urban migrants. The major source of calories were carbohydrates. Cereals and starchy root consumption were higher in rural siblings, though the proportion of energy from carbohydrate was almost similar in both study groups. In rural Bangladesh, people usually consume rice in three meals per day, whereas in urban areas, wheat consumption is more common at breakfast (368). Another cross-sectional survey conducted in rural and urban Bangladesh reported that carbohydrate intake was 189.85 g per capita a day for urban area whereas it was quite higher in rural areas (260.09 g/capita/day) (370). The result showed that in both urban and rural areas, carbohydrate based foods were the most common food items and major source of energy.

4.5.1.3 Smoking, smokeless tobacco and alcohol intake

Smoking (i.e., *cigarette, bidi*) was more prevalent in rural-to-urban migrants than rural siblings whereas the smokeless tobacco use such as zarda, *gul*, *pan-masala* and more, was higher in rural siblings compared to rural-to-urban migrants. In the UHS analysis (Chapter 2) we found that cigarette smoking was higher in life-long urban dwellers than among migrants, thus, we can confirm a pattern of smoking prevalence, i.e lowest in rural dwellers, highest in urban dwellers with migrants in between. A similar gradient was observed in the Peru migrant study where migrants' prevalence was an intermediate value between the prevalence seen among rural and urban groups (87). However, in the IMS (86) and the multi-country study (81), the rural dwellers reported the highest prevalence of smoking than those reported by migrants or urban dwellers .

Although smoking is considered impolite behaviour in Bangladesh, smokeless tobacco with betel quid is highly culturally acceptable, although it is responsible for various NCDs (139, 371). The dual exposure of smoking and smokeless tobacco put Bangladeshi men at higher risk of NCDs. The NCD risk factor survey 2010 of Bangladesh showed that the prevalence of smokeless tobacco was slightly lower in urban areas (30.8%) than rural areas (35.1%) (135). In the current sibling study, the prevalence of smokeless tobacco was higher in rural siblings than rural-to-urban migrants, which may suggest that migrants were acculturing the urban way of smoking. Considering the public health consequences of smokeless tobacco (371), a culturally appropriate public awareness campaign will be required for both migrants and rural residents.

Alcohol consumption is not socially or culturally acceptable norm in Bangladesh, which also reflects in the results of this study. The prevalence was very low in both groups; nevertheless, in migrants the proportion of alcohol users was slightly higher. In the UHS analysis, we also found that alcohol intake was higher in urban dwellers than urban migrants (Chapter 2). The Peru migrant study showed heavy drinking in the last year was similar between the urban, migrant, and rural groups (201), however, the pooled analyses of WHO-SAGE study showed significantly lower alcohol consumption in urban and migrant groups compared to rural dwellers (81). Hence, there is some inconsistency across countries in relation to patterns of alcohol consumption.

4.5.1.4 Mental health disorders

In this study, the prevalence of 'probable case of mental disorder' was higher in rural-to-urban migrants than the rural siblings (16.8%). The UHS analysis showed that migrant men were more prone to suffer mental disorders than lifelong urban dwellers (19.1% vs 16.8%) (Chapter 2). It can therefore be assumed that migrant men were more vulnerable to psychological illness than lifetime rural and urban dwellers. Mental illness may be due to an underlying genetic disposition, however, here we partially control for this by looking at dependant pairs, suggesting environmental factors influencing migrants may have driven the differences between siblings. After moving from a rural area to urban life, adjustment and settlement in the urban area may induce stress. Other factors could be missing family and social networks, reduced social support or economic deprivation (218). After adjusting for demographic variables, migrants were found to be three times more at risk of developing a mental health disorder than their rural siblings. Another rural-to-urban cross-sectional migration study conducted in Dhaka and adjacent rural area of Bangladesh also reported that the prevalence of poor mental condition was higher in migrants (60%) than rural residents (39%) and the urban group (54%) (218).

4.5.1.5 Metabolic risk factors

Our results are comparable to other migrant studies (81, 83, 84, 86, 87, 92, 194, 352) where the risk profile of migrants was greater than rural group. In the UHS migrant study (Chapter 2) we could compare the cardiovascular risk profiles of migrants with the host population but were not able to make comparisons with the place of origin. This study enables comparison of migrants from the place where they have come from. Although the magnitude of the difference in BMI was not that high between groups, skinfold thickness were substantially different (β=17.22mm) between the study groups even after adjusting for socio-demographic factors, energy intake and energy expenditure. Similar findings have been reported in studies from Peru (87) and Guatemala (84). These particular characteristics, (i.e, low BMI and excess body fat), have also observed in other studies of Indian Asians (70, 372). Besides this genetic trait, food habits and marked decrease in physical activity might be possible important reasons for the significant difference in body fat among migrant and rural siblings.

Migrants had a higher prevalence of dyslipidemia than their rural counterparts. Migrants were also around 3 times more likely to have low HDL levels than their rural siblings. It seems possible that these results are due to the low intake of fruit, vegetables and fish, which leads to low PUFA intake and subsequently worsened serum lipid profile in migrants. Migrants had slightly higher FBG and OGTT (0.54 mmol/l and 0.92 mmol/l) than rural siblings in the full adjusted model. In the Indian sibling study, the difference in FBG between migrants and rural siblings was 1.02 mmol/l (in men) (86). For blood pressure, while the mean value of systolic and diastolic BP were higher in rural siblings than rural-to-urban migrants, this trend was reversed after including treatment with antihypertensive drug. It indicates that more migrants might be on treatment to manage their blood pressure and, thus, pushing the mean blood pressure of migrants to be lower compared to their rural siblings. However, the systematic review also indicated the inconsistent pattern of hypertension in the previous migration studies (74) .

4.5.2 Migration, acculturation and CVD risk factors

Language spoken at home is considered as a proxy measure of acculturation. This study suggests acculturation was under way in migrants as around two-third of migrants used only standard dialect or both standard or local dialect of Bengali language to communicate with their spouse or children and friends. Although most of the migrants (90%) used local dialect with their parents, it decreased to one-third while communicating with their spouse, children and friends. In case of diet, dietary changes following migration emerge as a significant indication of acculturation.

Dietary changes may occur in many forms such as choosing fast food or processed food over traditional food for convenience, and changes to cooking habits especially using the traditional recipe or changes to meal formats (373). In this study, more than two-thirds of the rural-to-urban migrants stated that they were consuming unhealthy items such as soft drinks, energy drinks, processed/canned foods and red meat more often since migrating to the city. Moreover, around half of the rural-to-urban migrants stated that they prepared traditional food less often or never compared to before migration to the city. Although we have asked only one question regarding physical activity which cannot reflect the context of physical activity change (i.e., leisure or work, intensity and frequency), more than one-third of rural-to-urban migrants believed they were less active than before migration.

Length of urban residence is widely used as a proxy measure of acculturation. In this study a general trend of higher levels of risk from rural non-migrants to urban migrants was observed. In the UHS data analysis (Chapter 2), we have also shown that CVD risk factors increase with time spent in an urban area and compared with other studies. In this study, we have added important behavioural (diet, physical activity) and metabolic (diabetes, central obesity, dyslipidemia) risk factors to adjust for in looking at trends in duration of exposure to city life. The risk of physical inactivity, inadequate fruit and vegetable intake, mental health disorder and low HDL were significantly higher in migrants than in rural siblings and tended to be higher in each tertile or successive decade of urban life exposure. Diabetes and hypertension did not show any significant gradient in the adjusted model, perhaps due to the small number of diagnosed cases. No consistent pattern was observed for hypertension in the published literature, with some studies showing length of residence in urban areas was positively associated with hypertension (75-77), while other studies reported recent rural-to-urban migrants were more likely to be hypertensive than long-term migrants (79, 80). The latter pattern may be related to the stress associated with migration, which eventually resolves by treatment or by developing resiliency. In the IMS, although a trend for higher levels of risk factors from non-migrants to migrants was observed for TC, TG and diabetes, no clear pattern was observed for HDL (120). Other studies (75, 76, 79, 374, 375) usually focused on the metabolic risk factors for CVD and there is a scarcity of studies on unhealthy diet, physical activity and acculturation.

4.5.3 Strength and limitations

Longitudinal design is seldom feasible and therefore most internal migration studies use cross-sectional comparison (74). However, the strength of the sibling-pair comparative design used here is to examine the impact of migration within clusters that share similarities in origin including genetics, rearing environment, culture, exposures to diet, micro-and macro rural environment. This allows for attribution of changes in the rural-to-urban migrants to the new environment interacting with new personal behavioural choices. An additional strength is the coverage of all established CVD risk factors in the same sample as well as using validated tools. Nevertheless, there are some shortcomings to this design. First, this study had lower response rates than we anticipated largely because of the complexity of the sibling-pair recruitment. This sibling-pair design is not familiar in Bangladesh and we need to get consent from both siblings to recruit them to the study. Another limitation is the low representation of women migrants to an extent that we couldn't include them in the analysis. Therefore, our finding is only generalised to rural-to-urban male migrants. In rural Bangladesh, women usually move to their husband's home after marriage which is sometimes far from their parents' home or other town. Thus, when we tried to recruit both siblings, we could not reach rural female siblings. Moreover, family members did not show interest to give contact details of female migrants because of safety issues, which was not the case for male migrants. This is a methodological issue of recruitment and should be considered in planning further research on rural-to-urban female migrants studies. We could have designed a stratified sampling procedure based on quota by gender. However, this would complicate the recruitment even further given migration to city is largely dominated by men and often women followed. A study on rural-to urban women migrants is greatly warranted because their risk of CVD is different to men and their process of adaptation and acculturation to urban life may be different to men.

4.6 Conclusion

To the best of our knowledge this is the first ever study in Bangladesh to disentangle the effect of rural-to-urban migration on CVD risk factors. For most of the CVD risk factors, the risk profile of the migrant was higher than the risk profile of the rural non-migrant. Migration was found to be associated with an increased sedentary lifestyle and reduced fruit and vegetable and PUFA intake in migrants, as compared with rural siblings, and this eventually contributed to higher mean BMI, skinfold thickness and lower HDL in migrants. A general trend for higher levels of risk factors from rural non-migrants to migrants was seen with a longer period of stay in urban area, though this was not uniform for all risk factors. Findings from this study may contribute to planning effective CVD preventive interventions, not only for urban dwellers as a whole, but also pre-migration interventions with a special focus on migrants from rural areas, even before migration or during the first year of settlement. For example, how to moderate stress levels with an active lifestyle and how to keep a balanced healthy diet as well as development of policies that promote active living.

Chapter 5

General Discussion

5. General Discussion

For the last few decades Bangladesh has been undergoing transformation in its demographic, socio-economic and political structure resulting in rapid urbanisation caused mainly by rural-to-urban migration (174). The rapid urbanisation of Bangladesh is likely to have profound implications for its population health profile and raises the concern that the chronic disease burden may be even higher for urban populations. Now this country is facing a dual burden of existing infectious diseases and the escalating rise of non-communicable diseases (NCDs). Cardiovascular diseases (CVD) are the largest component of NCDs (33) and have been emerging as an important public health problem in Bangladesh.

The series of studies presented in this thesis were designed to assess the effect of rural-to-urban migration on CVD risk factors, and to validate diet and physical activity tools to assess behavioural risk factors of CVD. The rural-to-urban migrants were prioritised because study on migration and CVD risk factors in Bangladesh are non-existent. The findings from the studies presented in this thesis may aid understanding of CVD risk factors in Bangladesh and to design future prospective studies on the effect of migration on CVD in particular, and health in general. It is hoped that, later on, the knowledge generated from this thesis will inform health professionals and decision-makers about future interventions and population based preventative strategies. Moreover, tools validated in this thesis could be used for surveillance of NCDs in Bangladesh. The strategy followed in this series of studies includes epidemiological research using an existing nationally representative Urban Health Survey (UHS) data *(Chapter 2)*, validating dietary and physical activity tools to use in the empirical study

(Chapter 3 a, b and c) and a sibling comparative study to compare CVD risk factors among migrants and their rural siblings *(Chapter 4)*.

This chapter describes a critical summary of the key study findings, strengths and limitations, as well as implications of the study findings and areas for future research. This discussion focuses on the effect of migration on CVD in in the context of Bangladesh.

5.1. Key findings and discussion

5.1.1 Migration studies

Key Findings from Objective 1: *To compare the prevalence of CVD risk factors among rural-to-urban migrants and non-migrants*

The main overall research objective of this thesis was to find out if there was any difference in CVD risk factors in the rural-to-urban migrant group compared to those who did not migrate. To address this issue, two studies were conducted. Firstly, an epidemiological research was conducted using an existing nationally representative Urban Health Survey (UHS) data collected in Bangladesh *(Chapter 2)*. Next, a sibling comparative study was designed to compare CVD risk factors among migrants and their rural siblings *(Chapter 4)*. Both chapters identified migration from a rural to urban area as a risk for CVD. In Chapter 2, comparisons were made between migrants and non-migrant urban residents. Although in this study we could not compare migrants with the origin population, the sibling-pair comparative study complements this gap by including a rural group.

In the UHS study *(Chapter 2)*, the risk profile of the migrant group was lower than the risk profile of the urban group for most of the CVD risk factors (overweight and obesity, hypertension, diabetes, smoking) except bidi smoking and mental health disorders, which were higher in rural-to-urban migrants. The risk profile of CVD differed in men and women. While smoking and alcohol intake were more prevalent in men and almost nil in women, prevalence of overweight and obesity, mental health disorders and hypertension were higher in women than men. In this study, important behavioural (diet, physical activity) and metabolic (diabetes, central obesity, dyslipidemia) risk factors could not assessed due to unavailability of data.

In the sibling-pair comparative study, we could include only men in the analysis (164 pairs) and excluded women because of low sample size of women (12 pairs). A wide range of cardiovascular risk factors were assessed including physical inactivity, dietary intake, smoking, mental health disorders, anthropometry, blood pressure, lipids, and glycaemic status. Using the rural group as baseline, this study demonstrates that the risk profile of the migrant group was higher in all CVD risk factors studied except blood pressure (both systolic and diastolic blood pressures). Although the mean values of systolic and diastolic blood pressure were higher in rural siblings than rural-to-urban migrants, this trend was reversed for the categorical variable after including treatment with an antihypertensive drug. It is plausible that either hypertension is a common risk factor for all Bangladeshis but treatment is more accessible in urban communities, or that the act of migration aggravated the problem to an extent that rural-to-urban migrants need to seek treatment. A before and after study would assist in elucidating the paths by which hypertension develops in this population.

This study confirms that low levels of physical activity and high sedentarism were more prevalent amongst urban migrants compared to their rural siblings, which supports a causal effect of migration rather than selection by pre-migration risk. It was observed that the main difference in the total activities between migrants and their rural counterparts were due to travel and leisure time activities rather than occupational physical activity. This indicates that although the work pattern among migrants did not change much, their travel and leisure time activities decreased after migration *(Chapter 4)*.

This study also indicates that migration from a rural area to a mega city like Dhaka has had an impact on migrants' diet. Migrants showed lower consumption of poly-unsaturated fatty acid (PUFA), fruits and vegetables and fish compared to their rural siblings. Total calorie and macronutrient (gm) intake was higher in rural individuals but the proportion of energy from each nutrient varied between these two distinctive groups. Although total energy consumption was higher in rural individuals, their mean BMI was lower (0.98 m/kg2) than in the migrant group. This interesting finding may be explained by a better energy balance experienced by rural siblings, given they reported higher energy expenditure from moderate-to vigorous physical activity than rural-to-urban migrants. The result showed that in both urban and rural areas, carbohydrate based foods were the most common food items and major source of energy *(Chapter 4)*.

Smoking (i.e., cigarette, bidi) was more prevalent in rural-to-urban migrants than rural siblings whereas the smokeless tobacco use such as zarda, *gul*, *pan-masala* and others, was higher in rural siblings than rural-to-urban migrants *(Chapter 4)*. In the UHS analysis *(Chapter 2)*, cigarette smoking was more prevalent in life-long urban dwellers than migrants, thus, we can confirm a pattern of smoking prevalence which was lowest in rural dwellers, highest in urban dwellers and the migrants were just in between. Alcohol consumption is not a socially or culturally acceptable norm in Bangladesh, which is reflected in the results of both studies with the prevalence of alcohol intake found to be very low in migrant men *(Chapters 2 and 4)*.

A higher proportion of 'probable cases of mental disorder' was found among rural-to-urban migrants than non-migrant urban dwellers for both genders *(Chapter 2)* and in rural siblings for men *(Chapter 4)*. It was observed that migrant and even non-migrant women were more prone to suffer mental disorders than both groups of men *(Chapter 2),* but for both genders it was more of a socio-economic phenomenon. As women were not included in the sibling-pair study, we cannot say whether the risk of mental disorders in women was higher or similar to the origin population. Further research is needed to explore the mental health disorders among migrant women in comparison to rural women and to determine the factors underlying this phenomenon.

Migration was found to be associated with increased physical inactivity, reduced fruit and vegetable intake and reduced PUFA intake (in migrants compared to their rural siblings), likely contributing to the worsened serum lipid profile observed in migrants. Migrants were nearly three times more likely to have low HDL level than their rural siblings. HDL can be improved through exercise and it is in line with the fact that rural-to-urban migrants also decreased their leisure time physical activity. The assessment of continuous outcomes in CVD risk factors shows that migrants had a consistently greater number of adverse measures than their rural siblings, with the exception of SBP and DBP, after adjusting for all confounders. These outcomes include BMI, skinfold thickness, HDL, TC/HDL ratio, fasting blood glucose and 2-hr

OGTT. Furthermore, it was found that the risk of being classified as diabetic was significantly higher among migrants than rural siblings only after adjustment for SES, but again it was attenuated and became insignificant when lifestyle factors (diet, physical activity) and BMI were included suggesting that these lifestyles explained most of the differences in diabetes risk *(Chapter 4)*.

Key Findings from Objective 2: *To find out whether the CVD risk factors in the rural-to-urban migrants vary by length of residence in the urban environment*

Another objective of this thesis was to explore whether the CVD risk factors amongst migrants vary by length of residence in an urban environment. We took length of urban residence as a proxy measure of acculturation and weight gain as the immediate consequence of adopting an unhealthy diet and reducing physical activity, which result from the acculturation process. The findings suggest that CVD risk factors increase with time spent in an urban area. However, the pattern and magnitude of these changes were not uniform and varied across risk factors and gender *(Chapter 2 and Chapter 4)*.

A consistent increase in risk was observed for obesity with longer duration of urban stay in migrant men and women *(Chapter 2)*. The increase of overweight and obesity after migration can be explained by sudden lifestyle change and adaptation, which is related to reduced consumption of fruit and vegetables and a decrease in physical activity. The sibling-pair study also showed that the risk of physical inactivity, inadequate fruit and vegetable intake and low HDL were significantly higher in migrants than in rural siblings and tended to be higher in each tertile or successive decade of urban life exposure *(Chapter 4)*.

While the risk of mental health disorders increased with longer periods of residence in an urban area among women, no significant gradient was observed for men in UHS study *(Chapter 2)*. However, in the sibling-pair comparative study, men showed an increasing risk of mental health disorders with the duration of urban stay *(Chapter 4)*. One reason for this could be that the tool used to assess mental disorder in both studies was different. Alternatively, it could be that the expectations for new life in the city did not meet reality due to unforeseen difficulties over the years, whereas life in a rural place was associated with greater certainty. The psychosocial determinants of CVD risk is an emerging area of research; feeling alienated, job stress, social isolation or loneliness apart from mental illness (depression, schizophrenia etc) have all been shown to increase the risk of CVD (376, 377). For example, personality characteristics or job strain can increase the risk of traditional risk factors through behavioural (physical inactivity, poor diet, smoking, heavy alcohol intake, bad sleep, non-adherence to medication etc) and biological (autoimmune nervous dysfunction, increase stress reactivity etc) pathways, and ultimately affect atherosclerosis development and progression (378). Further research is needed in this area as migration has been associated with an increase in these feelings, which may affect the CVD metabolic biological risk factors.

An interesting finding among rural-to-urban migrants was observed in the present study in that cigarette smoking increased with time spent in urban living, whereas bidi smoking decreased with length of urban living. Given bidi is more prevalent in rural areas, this practice appeared to dissolve over time among these migrants. This was an indication that acculturation happened over years in the study groups *(Chapter 2)*. In the sibling-pair study, a significant trend for higher consumption of smoking from rural non-migrants to migrants was seen for the unadjusted OR, but these were attenuated with further adjustment by demographic and socio-economic status *(Chapter 4)*.

Diabetes and hypertension did not show any significant gradient in the adjusted model *(Chapter 2 and Chapter 4*). It was discussed previously that hypertension did not follow any pattern in our studies and other studies as well. In the UHS study blood glucose level was measured by fasting capillary blood glucose (FCBG) which is not reliable for diagnosis of diabetes. For this, there was always a chance of misclassification in the absence of an oral glucose tolerance test (OGTT) or fasting plasma glucose (FPG). Although we have conducted the OGTT in sibling-pair comparative study, no clear pattern of high diabetes risk was found with increasing duration of urban living, which may be due to the small number of diagnosed cases of diabetes. Further studies with a larger sample size and use of the OGTT needs to be considered.

Key Findings from Objective 3: *To examine the distribution of CVD risk factors among rural-to-urban migrants according to the environment they settled in: urban areas (division and slum/non-slum)*

Our third objective is to find out whether CVD risk factors vary by place of residence. It is likely that the pattern of CVD risk factors is not the same in different urban areas due to the differences in man-made and natural environments, such as availability of fast food, transport or opportunity for physical activity. We took urban areas of six divisions of Bangladesh and classified into three domains including slum and non-slum areas of City Corporation, and district municipalities. It was found that the proportion of CVD risk factors also varied by urban place of residence.

Hypertension as well as overweight and obesity were more prevalent in non-slum than slum areas, whereas mental health disorders, and cigarette and bidi smoking were higher in slum areas and District Municipalities than non-slum areas. In comparison among City Corporations, Dhaka and Sylhet, non-slum women migrants had higher metabolic risk factors (e.g., overweight and obesity, diabetes and hypertension) than other cities. For men, the proportion of metabolic risk factors was highest in Rajshahi City followed by Sylhet and Dhaka. The regional variation of CVD risk factors may be due to different level of urbanicity, an area which needs further exploration.

Mental health disorders had a significant SES gradient for both lifelong urban residents and migrants to city *(Chapter 2)* with poverty, lack of resources to overcome daily hardships, poor access to treatment and stigma acting together to preserve mental health inequality. It is possible that through SES mobility by better education and better earning and job opportunities, for slum residents in particular, that this cycle may be resolved in the future, but this will require strategic efforts from policy-makers.

5.1.2 Lessons learnt from validation studies

In this thesis we have presented three validation studies on physical activity and diet. Key findings are described here in brief.

Key Findings from Validity Study 1 Objective 1:*To validate the new version of the Global Physical Activity Questionnaire (GPAQ) among rural and urban residents in Bangladesh*

In this study we aimed to determine the criterion validity of the new version of the GPAQ (used in the WHO NCD risk factors surveillance in Bangladesh) in both rural and urban populations, using accelerometer as the criterion measure of physical activity. To the best of our knowledge this is the first validation study of the new version of the GPAQ in Bangladesh using accelerometer and also including rural population.

The results demonstrated moderate evidence of criterion related validity for total GPAQ MVPA and all domains of MVPA for urban participants but poor criterion validity for rural participants. The GPAQ demonstrated fair-to-moderate criterion validity for women, young adults (≤35 years) and those with a higher level of education. Bias towards over estimation of GPAQ MVPA with increased activity levels for urban and rural residents can explain the overall moderate performance of this measure *(Chapter 3a)*. Yet, this validation study questioned the suitability of accelerometer as a criterion measure in developing countries, where the main source of energy expenditure is occupation, and many labourer jobs involved strenuous upper body movements not captured by accelerometer. Further research using a combination of physical activity instruments (for example, heart monitors) are required to understand whether GPAQ performed poorly due to questionnaire burden or due to inappropriate validation criterion. In addition, in a population where leisure-time exercise is nearly non-existent, it will be interesting to test whether self–report intensity level is generally in agreement with the physiological effort of the reporter.

Key Findings from Validity Study 2 Objective 2: *To assess the validity of a newly developed, culturally relevant Past Year Physical Activity Questionnaire (PYPAQ) in rural and urban Bangladeshis.*

The questionnaire was designed to assess habitual, culturally relevant activities in different domains over the past year, for adults of both genders aged 18-60 years in urban and rural settings in Bangladesh. The results suggest modest concurrent and construct validity for the PYPAQ when compared to GPAQ and various health measures.

Comparing the PYPAQ with the GPAQ, overall the results showed an acceptable level of association. Analysis by residence showed stronger correlation for urban compared with rural dwellers. For urban residents, moderate to substantial correlation was found for total MVPA and MVPA in the travel and work domains, but low correlation was observed for leisure time activity. Among rural residents, fair to moderate correlation was found between the PYPAQ and GPAQ for total MVPA and work, travel and leisure time MVPA.

We found negative associations between anthropometry and metabolic factors, and most physical activity domains. Although some correlations are only poor to moderate, the direction of the correlations was generally as expected. Compared to accelerometer data, the PYPAQ showed poor validity for the rural residents and fair validity for the urban residents *(Chapter 3b)*. This enhanced the notion that accelerometer is not a good criterion for capturing physical activity in a rural living setting.

Key Findings from Validity Study 2 Objective 3: *To detect seasonal variation in energy expenditure and in prevalent activity types in each domain, and to assess seasonal variation for rural and urban residents.*

Another objective was to examine the seasonal variation of physical activity in rural and urban residents. Overall, marked differences were found in patterns of physical activity between rural and urban residents, with urban participants reporting much lower levels of energy expenditure than rural participants in all seasons. Seasonal variations in energy expenditure were significant only among rural residents and in most domains with the exception of household and transport. Despite the relatively comfortable temperature during autumn and late autumn, when occupational physical activity of rural residents is low, leisure time physical activity did not peak. Prevalent leisure time physical activity in Bangladesh were those that are easily accessible; walking, swimming and bicycling, but the level of participation in these activities were substantially lower in urban than in rural area *(Chapter 3b)*.

Key Findings from Validity Study 3 Objective 4: *To validate the FFQ using the 24-hour recall method and corresponding nutritional biological markers among rural and urban populations in Bangladesh.*

The aim of this subchapter was to validate FFQ against an average of three 24-hour recalls and several nutritional biomarkers among urban and rural Bangladeshis. We found fair to moderate agreement for ranking energy, and macro and micronutrients into quartiles with 24-hour recalls. The FFQ tends to underestimate most nutrients at low intakes and overestimate at higher intakes, while the correlation coefficients all indicate good correlation. In subgroup analysis, most of the nutrients correlated better among urban residents. In relation to biomarkers, FFQ estimates of sodium, folate and iron correlated better with corresponding biomarkers *(Chapter 3c)*.

Validation studies raise the notion of biases associated with education level; the ability to understand what is asked, the accuracy of recall and ability to compute sum of hours or times per week may introduce systematic bias by education level. Future studies should validate these questionnaires by stratified sampling of comparable proportions of each education levels. It may prove necessary to adapt each questionnaire to an illiterate population with a greater recall aid.

5.2 Overall strengths of this study

The following are the strengths of the present series of studies:

- Initially, a secondary data analysis has been done on UHS data to assess the proportion of CVD risk factors, examine associations with duration of urban stay and distribution of risk factors by residence among rural-to-urban migrants, an area of inquiry which had not been explored previously in Bangladesh. Further, the findings are robust given adjustment for a wide range of socio-economic factors that were assessed in the UHS.

  This is a nationally representative survey throughout the City Corporations and a sample of District Municipalities of Bangladesh. Thus, there was an opportunity to examine the distribution of CVD risk factors among rural-to-urban migrants according to the different urban areas (division and slum/non-slum) *(Chapter 2)* and separately for men and women. An important aspect of the present finding is that women migrants are more vulnerable than any other group in terms of metabolic risk factors and mental health disorders.

  The idea to do the empirical study among rural-to-urban migrants and their non-migrant rural siblings emanated from this chapter.

- The estimation of the role of SES in explaining differences between migrant and non-migrant is another gap in research, previously not reported in Bangladesh. Technical reports from the UHS concentrated on the distribution of the CVD risks but no analytical approaches had been used previously to delineating the role of SES. Our analysis indicated that SES is a strong determinant of CVD risk factors for both migrants and non-migrants.

Following stratification, the differences between the two groups mostly disappeared, with the exception of women, when we found that high SES increased the risk of high BMI and possibly diabetes for migrants and low SES may have protected migrants from obesity and diabetes possibly due to their active lifestyle.

- Most internal migration studies have used a cross-sectional design and independent groups for comparison. The strength of the sibling-pair comparative design used in Chapter 4 is in the ability to examine the impact of migration within clusters that share similarities at origin (genetics, rearing environment, culture, same exposures to diet), and therefore can attribute changes in the rural-to-urban migrants to the new environment interacting with the new personal behavioural choices.

- Another strength is the evaluation of a wide number of established CVD markers, including behavioural risk factors (physical activity, diet, smoking, alcohol intake), anthropometrics (BMI, waist circumference, waist hip ratio, waist height ratio, skinfold thickness), blood pressure, blood glucose (fasting, OGTT) and lipid profile (TC, TG, HDL, LDL).

- Validated tools were used in the sibling study to measure physical activity and diet to minimise the measurement error.

- Although the sibling-pair design is not common in Bangladesh and we faced difficulties in obtaining consent from both siblings to recruit them to the study, targets for enrolment of participants into the study were achieved *(Chapter 4)*.

- In the validity study we collected data from each participant five times. We tried our best to reduce lost to follow up through this regular communication with participants.

- In the first validity study, we validated the GPAQ-2 both in urban and rural population, which is rare in Bangladesh and in general. Further, there was good compliance with accelerometer wear and adherence to the study protocol *(Chapter 3a).*

- The second validity study is the first to develop a questionnaire (PYPAQ) to assess long-term participation in physical activity that extends beyond the past week. This study also allowed examination of seasonal variations across all domains in the rural and urban contexts *(Chapter 3b)*.

- The main strength of the third validity study was in validating the FFQ against multiple 24-hour recall and biomarkers among rural and urban participants. Previously the FFQ was validated against another dietary intake measurement (food diary) without the use of biomarker measures, and only on rural Bangladeshis. Moreover, we have expanded the food list with frequently consumed and local foods in Bangladesh according to the recommendations of the previous FFQ (308) study.

  We have used the Food Composition Table (FCT) of Bangladesh (312), United States Department of Agriculture (USDA) Nutrient Database (316) and Indian food composition table (317) to derive nutrient and energy estimates from dietary data. However, we have calculated nutrient value and yield factor of a number of local foods which were not available in any FCT *(Chapter 3c)*.

- Quality assurance procedures were maintained during fieldwork including training of research supervisor, assistants and phlebotomist for interview and clinical measurements as well as for blood sample collection and management of laboratory samples. Additionally, supervision during data collection and checking each questionnaire for missing values or irrelevant answers was conducted to minimise avoidable sources of measurement error *(Chapter 3 and 4)*.

- Good quality of data were generated and checked twice after entry. A very low number of missing values and inconsistencies were observed *(Chapter 3 and 4)*.

- Appropriate statistical tests were applied for categorical and continuous outcomes, and an advanced statistical approach was taken where applicable *(Chapter 2, 3 and 4).*

5.3 Overall limitations of this study

This thesis contains a total of five studies, which have some limitations. Briefly:

- In the UHS study the main limitation was the cross-sectional design that cannot examine the causality.

- Secondly, we compared the health status of migrants with urban dwellers; however, the more appropriate approach is to compare migrants with the benchmark, i.e. - similar people of origin.

  A further limitation is measurement bias. In this study we could not examine the smoking and alcohol behaviour among women because of very small positive response rate, which we assume happened due to social desirability. Diabetes and hypertension were measured among sub-samples aged >35 years and excluded District Municipalities, thus results of this study cannot extend to younger and all urban populations especially for people from smaller towns. Moreover, capillary blood glucose was taken for diabetes measurement, which is not a diagnostic measure unlike the OGTT.

- Lastly, some important behavioural (diet, physical activity) and metabolic (central obesity, dyslipidemia) risk factors data are absent in this study *(Chapter 2)*.

- In the sibling-pair comparative study, we tried to address the limitations of Chapter 2 *(Chapter 4)*. However, the main shortcoming of this study is a lower response rate (41%) than we anticipated, largely because of the complexity of the sibling-pair recruitment. Thus, there is a possibility of selection bias as those who did not give consent may be at more or less risk of CVD than who participated.

- Another limitation is the low representation of women migrants to such an extent that we couldn't include them in the analysis. Therefore, our finding is only generalisable to rural-to-urban male migrants *(Chapter 4)*.

- In the validity study, our urban sample is selected from a worksite therefore caution should be applied regarding generalisation to urban residents, although our sampling methods ensured urban residents from all SES were included *(Chapter 3a, 3b and 3c)*.

- One of the methodological limitations of the physical activity validity studies was that we used a triaxial Actigraph accelerometer as a reference measure for criterion validity. The gold standard measures for assessing energy expenditure are indirect calorimetry, doubly labelled water or heart rate monitoring, however, these are expensive and require technical expertise for implementation. In this study, accelerometer data likely underestimated MVPA in the rural sample due to its inability to capture water-based, non-ambulatory and static activities *(Chapter 3a and 3b)*.

- We acknowledge recall bias of the PYPAQ that may lead to under- or over-reporting of activity levels. It was easier for participants to recall their more recent physical activity accurately than their physical activity in the more distant past. Moreover, participants were asked to recall the time they spend on certain activities in hours or minutes but in rural settings, people are less likely to watch the clock.

- Secondly, we suspect participants had a tendency to over-report physical activity due to cultural and social desirability factors. Another bias is recall bias, which is particularly associated with education level of participants, as the ability to understand what is asked, the accuracy of recall and ability to compute the sum of hours or times per week may introduce systematic bias by education level. *(Chapter 3b)*.

- Although recovery biomarkers are considered gold standard for FFQ validity, the expense, availability of these biomarkers and technical expertise of implementation limited their use in this study.

- Another limitation of this study could be that we did not consider nutrient retention factors for cooked foods *(Chapter 3c)*.

5.4 Implication of the thesis findings for policy and planning

Internal migration is one of the important phenomena of any country and Bangladesh is no exception. It is projected that Bangladesh will be an urban country in 2039, transitioning from a rural country (66.5% of the population lived in rural areas in 2014) mostly because of the urban growth driven by migration from rural areas (124). This raises the concern that the chronic disease burden could be accelerated in migrants due to adaptation of unhealthy lifestyles in a short time. Bangladesh has made remarkable progress in fertility and mortality reduction, and improvements in the health and education sectors in the last few decades. Now is the time to pay particular attention to urbanisation and urban health, with a special focus on urban migrants, to combat NCDs.

The findings of this study are important for increasing our understanding of the migrant population, whose health issues are often overlooked. It is expected that the outcome of the studies would draw the attention of policy makers, healthcare providers and researchers, as it provides clear evidence that CVD risk factors among the rural-to-urban migrants are quite high or even at the similar level of urban non-migrants, and that substantial differences exist in CVD risk profile in migrant and rural non-migrants. These studies help to fill the knowledge gap on NCDs and CVDs risk factors in Bangladesh and other similar LMICs.

Bangladesh has quite a number of national policies and strategies for NCDs such as, the National Guidelines for Management of Hypertension in Bangladesh (DGHS MoHFW, 2013), Guidelines for Care of Type 2 Diabetes Mellitus in Bangladesh (BIRDEM, 2003), and National Strategic Plan of Action for Tobacco Control 2007 –

2010 (MoHFW, 2007), all of which are targeted towards specific NCDs. Moreover, the Government of Bangladesh introduced numerous initiatives to combat chronic NCDs. The first National Strategic Plan for Surveillance and Prevention of Non-Communicable Diseases in Bangladesh 2007–2010 was issued in 2007 and the new Health, Nutrition and Population Sector Intervention Program (HNPSIP, 2016–2021) also highlighted the need to tackle the rising burden of NCDs, and promote healthy lifestyles and healthy environments (379, 380). This study generates evidence that targeting migrants and their families before migration and at the first year of settlement with health promotion activities around preventing risk factors for CVD, may help to slow the progress of the epidemic and thus it is necessary to include internal migrants' health as a focus at the national policy level. Moreover, since CVDs and all other NCDs share common risk factors, the findings can be extrapolated, painting an alarming picture for health care planners prompting them to emphasise and accelerate their comparatively recent attempts to prioritising NCDs in health care and human resource development programs.

Programs focused on preventing metabolic risk by addressing behavioural risk factors in new migrants to urban areas could deliver long-term health benefits. SES should be considered while designing intervention as it was found that the risk profile is different in slum and non-slum migrants. An important aspect of the present finding is that women migrants are more vulnerable than any other groups in terms of metabolic risk factors and mental health disorders. Currently, Bangladesh is the world's leading clothing exporter and many females are migrating from rural areas to big cities like Dhaka and Chittagong to work at garment factories. As around 80% of garment workers are women, and most of them are poor, unskilled, sometimes illiterate, and often single women in a highly gender biased society (381), our findings may provide evidence to promote healthy lifestyles within this industry. Intervention need to start immediately with by raising awareness of risk factors to reduce their impact among female migrants.

This study validated a number of tools to assess behavioural risk factors, which could be considered in the national NCD risk factor surveillance and further research. Use of the culturally relevant PYPAQ developed during this PhD candidature, highlighted strong seasonal variation in physical activity in the rural residents of Bangladesh and the much lower level of physical activity in urban residents in all seasons. Understanding how seasonality influences level of physical activity will allow for more accurate physical activity surveillance in the future. For example, the GPAQ tool of the WHO STEPS survey should be used along the year, allowing all seasons to be represented. This is more likely to produce an accurate estimate of high, medium and low active groups. It will also assist in developing seasonally appropriate physical activity interventions. Moreover, a number of local foods were weighed and their nutrient values and yield factors calculated, which could be used in future dietary research.

5.5 Future direction

Based on the study findings, the following recommendations are made:

- A longitudinal study design is ideal where measurements could be made prior to and after migration, and participants followed for several years to examine how CVD risk evolves over time in relation to migration. Such a study needs to be conducted to better understand CVD and its risk factors.

- As the risk profile of CVD is different in men and women, there is particular research needed on migrant women.

- We faced the challenge of the methodological issue of recruitment of female participants, which should be considered in planning further research on rural-to-urban female migrants. In rural Bangladesh, women usually move to their husband's home after marriage, which is sometimes far from their parents' home or other town. Thus, when we tried to recruit both siblings, we could not reach rural female siblings. Moreover, family members were not inclined to give contact details for female migrants because of safety issues, which was not the case for male migrants.

- Further in-depth studies are needed to focus on CVD risk factors in small cities and to explore the reasons for the regional variations we observed *(Chapter 2)*.

- Mental illness is still overlooked in Bangladesh due to lack of knowledge, superstitious beliefs and social stigma, which inhibit people from seeking medical treatment. This situation is even worse among rural-to-urban migrants and women. An awareness campaign should be conducted and focused on these vulnerable groups.

- The present series of validity studies showed acceptable validly of the physical activity and dietary tools, however, now continued research is needed to enhance its validity with criterion measure, reliability study and stratification by education levels.

- As there is hardly any nationally representative data on CVD risk factors among migrants, national surveys on health should consider inclusion of these factors. The Bangladesh Demographic Health Survey (BDHS) is a periodical nationwide survey held every four years in Bangladesh. If information on migration and CVD risk is included in this survey, trends of CVD risk could be monitored among migrants. The Urban Health Survey is another important survey that has been held twice (2006 and 2013) in Bangladesh. It was designed to examine the conditions of the urban population in Bangladesh with explicit attention to the differences between slum and non-slum groups. Although information on migration and few CVD risk factors were included in 2006 survey, information on CVD risk factors was removed in the 2013 survey. We would recommend including it in any future surveys.

6. References

1. El-Saharty S, Ahsan KZ, Koehlmoos TL, Engelgau MM. Tackling noncommunicable diseases in Bangladesh. Washington DC, USA: World Bank; 2013.

2. McAloon CJ, Boylan LM, Hamborg T, Stallard N, Osman F, Lim PB, et al. The changing face of cardiovascular disease 2000–2012: An analysis of the world health organisation global health estimates data. International journal of cardiology. 2016;224:256-64.

3. World Health Organization. Noncommunicable diseases [Available from: http://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases.

4. World Health Organization, World Heart Federation, World Stroke Organization. Global Atlas on cardiovascular disease prevention and control. Geneva: World Health Organization, World Heart Federation, World Stroke Organization,; 2011.

5. Modesti PA, Agostoni P, Agyemang C, Basu S, Benetos A, Cappuccio FP, et al. Cardiovascular risk assessment in low-resource settings: a consensus document of the European Society of Hypertension Working Group on Hypertension and Cardiovascular Risk in Low Resource Settings. Journal of hypertension. 2014;32(5):951.

6. Barquera S, Pedroza-Tobías A, Medina C, Hernández-Barrera L, Bibbins-Domingo K, Lozano R, et al. Global overview of the epidemiology of atherosclerotic cardiovascular disease. Archives of medical research. 2015;46(5):328-38.

7. World Health Organization. Global status report on noncommunicable diseases 2010. Geneva: World Health Organization (WHO); 2011.

8. Yusuf S, Reddy S, Ounpuu S, Anand S. Global burden of cardiovascular diseases Part II: variations in cardiovascular disease by specific ethnic groups and geographic regions and prevention strategies. Circulation. 2001;104:2855-64.

9. Wong ND. Epidemiological studies of CHD and the evolution of preventive cardiology. Nature Reviews Cardiology. 2014;11(5):276.

10. Roth GA, Johnson C, Abajobir A, Abd-Allah F, Abera SF, Abyu G, et al. Global, regional, and national burden of cardiovascular diseases for 10 causes, 1990 to 2015. Journal of the American College of Cardiology. 2017:23715.

11. World Heart Federation. Fact Sheets- Cardiovascular disease by country [Available from: https://www.world-heart-federation.org/resources/factsheets/.

12. Yousuf SH, S; Ounpuu, S; Dans,T; Avenzum, A; Lanas, F. Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case-control study. Lancet. 2004;364:937-52.

13. Turin TC, Shahana N, Wangchuk LZ, Specogna AV, Al Mamun M, Khan MA, et al. Burden of cardio-and cerebro-vascular diseases and the conventional risk factors in South Asian population. Global heart. 2013;8(2):121-30.

14. Padmanabhan S, Hastie C, Prabhakaran D, Dominczak AF. Genomic approaches to coronary artery disease. The Indian journal of medical research. 2010;132(5):567.

15. World Health Organization. Noncommunicable diseases country profiles 2014. 2014.

16. Zubair F, Nawaz SK, Nawaz A, Nangyal H, Amjad N, Khan MS. Prevalence of cardiovascular diseases in Punjab, Pakistan: a cross-sectional study. Journal of Public Health. 2018:1-7.

17. Ghaffar A, Reddy KS, Singhi M. Burden of non-communicable diseases in South Asia. BMJ: British Medical Journal. 2004;328(7443):807.

18. Anjomshoa M, Yasin Y, Salahshoor M. GBD 2017 Mortality Collaborators. Global, regional, and national age-sex-specific mortality and life expectancy, 1950-2017: a systematic analysis for the Global Burden of Disease Study (vol 392, pg 1684, 2018). Lancet. 2019;393(10190):E44-E.

19. World Health Organization (WHO). Global health and aging. World Health Organization (WHO), National Institute of Aging and National Institute of Health; 2011.

20. United Nations. World population prospects: The 2012 revision, highlights and advance tables. United Nations Economic and Social Affairs. 2013;Working Paper No. ESA/P/WP.228.

21. Foot DK, Lewis RP, Pearson TA, Beller GA. Demographics and cardiology, 1950–2050. Journal of the American College of Cardiology. 2000;35(4):1067-81.

22. Odden MC, Coxson PG, Moran A, Lightwood JM, Goldman L, Bibbins-Domingo K. The impact of the aging population on coronary heart disease in the United States. The American journal of medicine. 2011;124(9):827-33. e5.

23. Nieto FJ. Cardiovascular disease and risk factor epidemiology: a look back at the epidemic of the 20th century. American Public Health Association; 1999.

24. Yusuf S, Reddy S, Ounpuu S, Anand S. Global burden of cardiovascular diseases: part I: general considerations, the epidemiologic transition, risk factors, and impact of urbanization. Circulation. 2001;104(22):2746-53.

25. O'Donnell MJ, Chin SL, Rangarajan S, Xavier D, Liu L, Zhang H, et al. Global and regional effects of potentially modifiable risk factors associated with acute stroke

in 32 countries (INTERSTROKE): a case-control study. The Lancet. 2016;388(10046):761-75.

26. World Health Organization. Noncommunicable diseases country profile 2011. Geneva: World Health Organization (WHO); 2011.

27. World Health Organization. The world health report 2002: reducing risks, promoting healthy life: World Health Organization; 2002.

28. Stanaway JD, Edvardsson D, Murray CJL. Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks for 195 countries and territories, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. The Lancet. 2018;392(10159):1923-94.

29. World Health Organization. Global status report on noncommunicable disaeses 2014. Switzerland: World Health Organization (WHO); 2015.

30. International Diabetes Federation. IDF Diabetes Atlas. International Diabetes Federation; 2017.

31. Zimmet PZ. Diabetes and its drivers: the largest epidemic in human history? Clinical diabetes and endocrinology. 2017;3(1):1.

32. Moran A, Vedanthan R. Cardiovascular Disease Prevention in South Asia Gathering the Evidence. Global heart. 2013;8(2):139.

33. World Health Organization. Cardiovascular diseases (CVDs) key facts [Available from: http://www.who.int/en/news-room/fact-sheets/detail/cardiovascular-diseases-(cvds).

34. World Health Organization, Public Health Agency of Canada. Preventing chronic diseases: a vital investment: World Health Organization; 2005.

35. Global health risks mortality and burden of disease attributable to selected major risks. 2009: World Health Organization (WHO) 2009.

36. Reddy KS. Cardiovascular diseases in the developing countries: dimensions, determinants, dynamics and directions for public health action. Public Health Nutrition. 2002;5(1A):231-7.

37. United Nations. World Urbanization Prospects: 2014 Revisions. Department of Economic and Social Affairs, United Nations; 2014.

38. United Nations, Department of Economic and Social Affairs, Population Division. The World's Cities in 2016– Data Booklet (ST/ESA/ SER.A/392)2016.

39. Addo J, Smeeth L, Leon D. Hypertension in Sub-Saharan Africa: a systematic review. Hypertension 2007;50:1012-18.

40. Abdul-Rahim HH-O, G; Stene, LCM; Husseini, A; Giacaman, R; Jervell, J; Bjertness, E. Obesity in a rural and an urban Palestinian West Bank population. International Journal of Obesity 2003;27:140-46.

41. Reddy SS, B; Varghese, C. Responding to the threat of chronic diseases in India. lancet. 2005;366:1744-9.

42. Hussain A, Rahim M, Azad Khan A, Ali S, Vaaler S. Type 2 diabetes in rural and urban population: diverse prevalence and associated risk factors in Bangladesh. Diabetic Medicine 2005;22:931-6.

43. Pan XY, WY; Wei, Li G, Liu, J. Prevalence of diabetes and its risk factors in China, 1994 Diabetes Care. 1997;20:1664-69.

44. Sayeed MA, L; Hussain, MZ; Karim, RiMA; Banu, A; Azad Khan, AK. Effect of socioeconomic risk factors on the difference in prevalence of diabetes between rural and urban population in Bangladesh. Diabetes Care. 1997;20:551-55.

45. Ali OT, TT; Sakina, O; Khalid, BAK; Wu, LL; Ng, ML. Prevalence of NIDDM and impaired glucose tolerance in aborigines and Malays in Malaysia and their relationship to sociodemographic, health and nutritional factors. Diabetes Care. 1993;16:68-75.

46. Ramachandran A, Mary S, Yamuna A, N M, C S. High prevalence of diabetes and cardiovascular risk factors associated with urbanization in India. Diabetes Care 2008;31:893-8.

47. Choi YJ, Cho YM, Park CK, Jang HC, Park KS, Kim SY, et al. Rapidly increasing diabetes-related mortality with socio-environmental changes in South Korea during the last two decades. Diabetes Research and Clinical Practice. 2006;74:295-300.

48. Sasakia H, Kawasakia T, Ogakia T, Kobayashib S, Itohc K, Yoshimizud Y, et al. The prevalence of diabetes mellitus and impaired fasting glucose/glycaemia (IFG) in suburban and rural Nepal—the communities-based cross-sectional study during the democratic movements in 1990. Diabetes Research and Clinical Practice. 2005;67:167-74.

49. Shera A, Jawad F, Maqsood A. Prevalence of diabetes in Pakistan. Diabetes Research and Clinical Practice. 2007;76:219-22.

50. Cyril S, Oldroyd JC, Renzaho A. Urbanisation, urbanicity, and health: a systematic review of the reliability and validity of urbanicity scales. BMC Public Health. 2013;13(1):513.

51. Van de Poel E, O'Donnell O, Van Doorslaer E. Is there a health penalty of China's rapid urbanization? Health economics. 2012;21(4):367-85.

52. Dahly DL, Adair LS. Quantifying the urban environment: a scale measure of urbanicity outperforms the urban–rural dichotomy. Social science & medicine. 2007;64(7):1407-19.

53. Allender S, Lacey B, Webster P, Rayner M, Deepa M, Scarborough P, et al. Level of urbanization and noncommunicable disease risk factors in Tamil Nadu, India. Bulletin of the World Health Organization. 2010;88:297-304.

54. Alam MJ, Alam M, Rahman M, Khan S, Munna G. Unplanned urbanization: Assessment through calculation of environmental degradation index. International Journal of Environmental Science & Technology. 2006;3(2):119-30.

55. Brownson RC, Boehmer TK, Luke DA. Declining rates of physical activity in the United States: what are the contributors? Annual Reviews Public Health. 2005;26:421-43.

56. French SA, Story M, Jeffery RW. Environmental influences on eating and physical activity. Annual Reviews Public Health. 2001;22:309-35.

57. Smith Sea. Urbanization and cardiovascular disease: raising heart-healthy children in today's cities. Geneva; 2012.

58. Islam N, Ullah G. Factors affecting consumers' preferences on fast food items in Bangladesh. 2010.

59. Angkurawaranon C, Jiraporncharoen W, Chenthanakij B, Doyle P, Nitsch D. Urbanization and non-communicable disease in Southeast Asia: a review of current evidence. Public health. 2014;128(10):886-95.

60. Jeemon P, Neogi S, Bhatnagar D, Cruickshank KJ, Prabhakaran D. The impact of migration on cardiovascular disease and its risk factors among people of Indian origin. Current Science. 2009:378-84.

61. Bangladesh Bureau of Statistics. Population distribution and internal migration in Bangladesh. Bangladesh: Bangladesh Bureau of Statistics, Statistics and Informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh; 2015.

62. Marceca M. Migration and health from a public health perspective. People's Movements in the 21st Century-Risks, Challenges and Benefits: InTech; 2017.

63. Boateng D, Agyemang C, Beune E, Meeks K, Smeeth L, Schulze M, et al. Migration and cardiovascular disease risk among Ghanaian Populations in Europe: The RODAM Study (Research on Obesity and Diabetes Among African Migrants). Circulation: Cardiovascular Quality and Outcomes. 2017;10(11):e004013.

64. Marmot M. Society and health of migrants. European journal of epidemiology. 2016;31(7):639-41.

65. Renzaho AM. Globalisation, migration and health: challenges and opportunities: World Scientific; 2016.

66. Odone A, McKee C, McKee M. The impact of migration on cardiovascular diseases. International Journal of Cardiology. 2018;254:356-61.

67. Østbye T, Welby T, Prior I, Salmond C, Stokes Y. Type 2 (non-insulin-dependent) diabetes mellitus, migration and westernisation: the Tokelau Island Migrant Study. Diabetologia. 1989;32(8):585-90.

68. Hara H, Egusa G, Yamakido M. Incidence of non-insulin-dependent diabetes mellitus and its risk factors in Japanese-Americans living in Hawaii and Los Angeles. Diabetic medicine: a journal of the British Diabetic Association. 1996;13(9 Suppl 6):S133-42.

69. Anand SS, Yusuf S, Vuksan V, Devanesen S, Teo KK, Montague PA, et al. Differences in risk factors, atherosclerosis, and cardiovascular disease between ethnic

groups in Canada: the Study of Health Assessment and Risk in Ethnic groups (SHARE). The lancet. 2000;356(9226):279-84.

70. Boon MR, Bakker LE, van der Linden RA, van Ouwerkerk AF, de Goeje PL, Counotte J, et al. High prevalence of cardiovascular disease in South Asians: central role for brown adipose tissue? Critical reviews in clinical laboratory sciences. 2015;52(3):150-7.

71. Bos V, Kunst AE, Keij-Deerenberg IM, Garssen J, Mackenbach JP. Ethnic inequalities in age-and cause-specific mortality in The Netherlands. International journal of epidemiology. 2004;33(5):1112-9.

72. Jin K, Ding D, Gullick J, Koo F, Neubeck L. A Chinese immigrant paradox? Low coronary heart disease incidence but higher short-term mortality in western-dwelling Chinese immigrants: a systematic review and meta-analysis. Journal of the American Heart Association. 2015;4(12):e002568.

73. Cortes-Bergoderi M, Goel K, Murad MH, Allison T, Somers VK, Erwin PJ, et al. Cardiovascular mortality in Hispanics compared to non-Hispanic whites: a systematic review and meta-analysis of the Hispanic paradox. European Journal of Internal Medicine. 2013;24(8):791-9.

74. Hernández AV, Pasupuleti V, Deshpande A, Bernabé-Ortiz A, Miranda JJ. Effect of rural-to-urban within-country migration on cardiovascular risk factors in low and middle income countries: A systematic review. Heart. 2012;98(3):185-94.

75. Kusuma Y, Gupta S, Pandav C. Migration and hypertension: a cross-sectional study among neo-migrants and settled-migrants in Delhi, India. Asia Pacific Journal of Public Health.21(4):497-507.

76. Gupta R, Gupta R, Agrawal A, Misra A, Guptha S, Pandey RM, et al. Migrating husbands and changing cardiovascular risk factors in the wife: a cross

sectional study in Asian Indian women. J Epidemiol Community Health. 2012;66(10):881-9.

77. Duboz P, Macia E, Chapuis-Lucciani N, Boëtsch G, Gueye L. Migration and hypertension in Dakar, Senegal. American journal of physical anthropology. 2012;149(2):250-8.

78. Varadharajan KS, Thomas T, Rajaraman D, Kurpad AV, Vaz M. Overweight and obesity among internal migrants in India. Asia Pacific journal of clinical nutrition. 2013;22(3):416-25.

79. Zhao J, Seubsman S-a, Sleigh A, Thai Cohort Study Team t. Timing of urbanisation and cardiovascular risks in Thailand: evidence from 51 936 members of the Thai cohort study, 2005–2009. Journal of epidemiology. 2014;24(6):484-93.

80. Doulougou B, Kouanda S, Rossier C, Soura A, Zunzunegui MV. Differences in hypertension between informal and formal areas of Ouagadougou, a sub-Saharan African city. BMC Public Health. 2014;14(1):893.

81. Oyebode O, Pape UJ, Laverty AA, Lee JT, Bhan N, Millett C. Rural, urban and migrant differences in non-communicable disease risk-factors in middle income countries: a cross-sectional study of WHO-SAGE data. PloS one. 2015;10(4):e0122747.

82. Norboo T, Stobdan T, Tsering N, Angchuk N, Tsering P, Ahmed I, et al. Prevalence of hypertension at high altitude: cross-sectional survey in Ladakh, Northern India 2007–2011. BMJ open. 2015;5(4):e007026.

83. Unwin N, James P, McLarty D, Machybia H, Nkulila P, Tamin B, et al. Rural to urban migration and changes in cardiovascular risk factors in Tanzania: a prospective cohort study. BMC public health. 2010;10(1):272.

84. Torun B, Stein AD, Schroeder D, Grajeda R, Conlisk A, Rodriguiz M, et al. Rural-ro-urban migration and cardiovascular disease risk factors in young Guatemalan adults. International Journal of Epidemiology. 2002;31:218-26.

85. Poulter NR, Khaw KT, Hopwood BC, Mugambi M, W S Peart GR, P S Sever. The Kenyan Luo migration study: observations on the initiation of a rise in blood pressure. BMJ. 1990;300:967-72.

86. Ebrahim S, Kinra S, Bowen L. The effect of rural-to-urban migration on obesity and diabetes in India: a cross-sectional study. Plos Medicine 2010;7(4):p.e1000268.

87. Miranda J, Gilman R, Smeeth L. Differences in cardiovascular risk factors in rural, urban and rural-to-urban migrants in Peru. Heart. 2011;97:787-96.

88. Carrillo-Larco RM, Bernabé-Ortiz A, Pillay TD, Gilman RH, Sanchez JF, Poterico JA, et al. Obesity risk in rural, urban and rural-to-urban migrants: prospective results of the PERU MIGRANT study. International journal of obesity. 2016;40(1):181.

89. Lazo-Porras M, Bernabe-Ortiz A, Málaga G, Gilman RH, Acuna-Villaorduna A, Cardenas-Montero D, et al. Low HDL cholesterol as a cardiovascular risk factor in rural, urban, and rural-urban migrants: PERU MIGRANT cohort study. Atherosclerosis. 2016;246:36-43.

90. Bernabe-Ortiz A, Sanchez JF, Carrillo-Larco RM, Gilman RH, Poterico JA, Quispe R, et al. Rural-to-urban migration and risk of hypertension: longitudinal results of the PERU MIGRANT study. Journal of human hypertension. 2017;31(1):22.

91. Gupta R, Deedwania PC, Sharma K, Gupta A, Guptha S, Achari V, et al. Association of educational, occupational and socioeconomic status with

cardiovascular risk factors in Asian Indians: a cross-sectional study. PloS one. 2012;7(8):e44098.

92. Yamauchi T, Umezaki M, Ohtsuka R. Influence of urbanisation on physical activity and dietary changes in Huli-speaking population: a comparative study of village dwellers and migrants in urban settlements. British Journal of Nutrition. 2001;85:61-73.

93. Bowen L, Ebrahim S, De Stavola1 B, Ness A, Kinra S, Bharathi A, et al. Dietary intake and rural-urban migration in India: a cross-sectional study. PLoS ONE. 2011;6(6).

94. Sullivan R, Kinra S, Ekelund U, Bharathi A, Vaz M, Kurpad A, et al. Socio-demographic patterning of physical activity across migrant groups in India: Results from Indian Migration Study. PLoS ONE. 2011;6(10):e24898. doi:10.1371/journal.pone.0024898.

95. Sullivan R, Kinra S, Ekelund U, Bharathi A, Vaz M, Kurpad A, et al. Evaluation of the Indian migration study physical activity questionnaire (IMS-PAQ): a cross-sectional study. International Journal of Behavioral Nutrition and Physical Activity. 2012;9(1):13.

96. Shin C-N, Lach HW. Acculturation and health of Korean American adults. Journal of Transcultural Nursing. 2014;25(3):273-80.

97. Delavari M, Sønderlund AL, Swinburn B, Mellor D, Renzaho A. Acculturation and obesity among migrant populations in high income countries–a systematic review. BMC public health. 2013;13(1):458.

98. Pérez-Escamilla R, Putnik P. The role of acculturation in nutrition, lifestyle, and incidence of type 2 diabetes among Latinos. The Journal of nutrition. 2007;137(4):860-70.

99. Tutu RA, Boateng J, Ameyaw EE, Busingye JD. Acculturation inclinations and subjective health status of internal migrants in James Town, an urban slum settlement in Accra. Journal of Population Research. 2017;34(2):165-83.

100. Berry JW, Phinney JS, Sam DL, Vedder P. Immigrant youth: Acculturation, identity, and adaptation. Applied psychology. 2006;55(3):303-32.

101. Chamchan C, Chan WK, Punpuing S. A longitudinal study of migration and health: Empirical evidence from Thailand and its implications. UNRISD Working Paper; 2014.

102. Lu Y. Mental health and risk behaviours of rural–urban migrants: Longitudinal evidence from Indonesia. Population studies. 2010;64(2):147-63.

103. Abel GJ, Sander N. Quantifying global international migration flows. Science. 2014;343(6178):1520-2.

104. Flannery WP, Reise SP, Yu J. An empirical comparison of acculturation models. Personality and Social Psychology Bulletin. 2001;27(8):1035-45.

105. Ayala GX, Baquero B, Klinger S. A systematic review of the relationship between acculturation and diet among Latinos in the United States: implications for future research. Journal of the American Dietetic Association. 2008;108(8):1330-44.

106. Schwartz SJ, Unger JB, Zamboanga BL, Szapocznik J. Rethinking the concept of acculturation: implications for theory and research. American Psychologist. 2010;65(4):237.

107. Berry JW. Immigration, acculturation, and adaptation. Applied psychology. 1997;46(1):5-34.

108. Thomson MD, Hoffman-Goetz L. Defining and measuring acculturation: a systematic review of public health studies with Hispanic populations in the United States. Social science & medicine. 2009;69(7):983-91.

109. Sam DL, Berry JW. The Cambridge handbook of acculturation psychology: Cambridge University Press; 2006.

110. Im E-O, Yang K. Theories on immigrant women's health. Health care for women international. 2006;27(8):666-81.

111. Van De Vijver FJ. Dimensions in acculturation: One, two, or many? Psihologia Resurselor Umane. 2015;13(1):32.

112. Berry JW, Kim U, Power S, Young M, Bujaki M. Acculturation attitudes in plural societies. Applied psychology. 1989;38(2):185-206.

113. Berry JW. Acculturation strategies and adaptation. 2007.

114. Padilla R, Steiner JF, Havranek EP, Beaty B, Davidson AJ, Bull S. A comparison of different measures of acculturation with cardiovascular risk factors in Latinos with hypertension. Journal of immigrant and minority health. 2011;13(2):284-92.

115. Bhugra DB, MA. Migration, culturally bereavement and cultural identity. World Psychiatry. 2005;4(1).

116. Chavez L. Culture change and cultural reproduction lessons from reaserch on transnational migration. Globalization and Change in Fifteen Cultures: Born in One world and Living in Another. Belmont, CA: Thomson-Wadsworth; 2006.

117. Hara HE, G; Yamakido, M. Incidence of non-insulin-dependent diabetes mellitus and its risk factors in Japanese-Americans living in Hawaii and Los Angeles. Diabetic Medicine. 1996;13:S133-S42.

118. Jaber L, Brown M, Hammad A, Zhu Q, Herman W. Lack of acculturation is a risk factor for diabetes in Arab immigrants in the U.S. Diabetes Care. 2003;26(7).

119. Carrillo-Larco RM, Bernabé-Ortiz A, Pillay TD, Gilman RH, Sanchez JF, Poterico JA, et al. Obesity risk in rural, urban and rural-to-urban migrants: prospective

results of the PERU MIGRANT study. International journal of obesity (2005). 2016;40(1):181.

120. Kinra S, Andersen E, Ben-Shlomo Y, Bowen L, Lyngdoh T, Prabhakaran D, et al. Association between urban life-years and cardiometabolic risk. American Journal of Epidemiology. 2011;174(2).

121. National Institute of Population Research and Training (NIPORT), Mitra and Associates, International I. Bangladesh Demographic and Health Survey 2014. Bangladesh: National Institute of Population Research and Training, Mitra and Associates, MEASURE DHS; 2016.

122. Bangladesh Bureau of Statistics. Bangladesh Population & Housing Census 2011: Analytical Report: Bangladesh Bureau of Statistics, Statistics and Informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh; 2015.

123. The World Bank. The World Bank in Bangladesh overview [Available from: http://www.worldbank.org/en/country/bangladesh/overview.

124. National Institute of Population Research and Training (NIPORT). Bangladesh Urban Health Survey 2013. Dhaka: National Institute of Population Research and Training (NIPORT), MEASURE Evaluation, International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B), and Associates for Community and Population Research (ACPR). ; 2014.

125. World Population Prospects: The 2010 Revision. New York: ESCAP Population data sheet 2012. United Nations, Department of Economic and Social Afairs, Population Division 2011.

126. Bangladesh Bureau of Statistics. Bangladesh Population amd Housing census 2011, Socioeconomic and Demographic Report. Dhaka, Bangladesh: Bangladesh

Bureau of Statistics, Ministry of Planning, Government of the People's Republic of Bangladesh; 2012.

127. Siddiqui. Migration as a Livelihood Strategy of the Poor: The Bangladesh Case. Refugee and Migratory Movements Research Unit, Dhaka University; 2003.

128. Afsar R. Internal migration and the development nexus: the case of Bangladesh. Dhaka: Bangladesh Institute of Development Studies, Dhaka, Bangladesh; 2003.

129. Skeldon R. Globalization, skilled migration and poverty alleviation: brain drains in context. 2005.

130. Naghavi M, Abajobir AA, Abbafati C, Abbas KM, Abd-Allah F, Abera SF, et al. Global, regional, and national age-sex specific mortality for 264 causes of death, 1980–2016: a systematic analysis for the Global Burden of Disease Study 2016. The Lancet. 2017;390(10100):1151-210.

131. Preliminary report on household income and expenditure survey 2010. Dhaka: Bangladesh Bureau of Statistics (BBS); 2010.

132. Islam AM, Majumder A. Coronary artery disease in Bangladesh: A review. Indian heart journal. 2013;65(4):424-35.

133. Islam AM, Mohibullah A, Paul T. Cardiovascular Disease in Bangladesh: A Review. Bangladesh Heart Journal. 2016;31(2):80-99.

134. Ahsan Karar Z, Alam N, Kim Streatfield P. Epidemiological transition in rural Bangladesh, 1986–2006. Global health action. 2009;2(1):1904.

135. Zaman MM, Rahman MM, Rahman MR, Bhuiyan MR, Karim MN, Chowdhury MA. Prevalence of risk factors for non-communicable diseases in Bangladesh: results from STEPS survey 2010. Indian J Public Health. 2016;60(1):17-25.

136. GBD Profile: Bangladesh [Available from: http://www.healthdata.org/sites/default/files/files/country_profiles/GBD/ihme_gbd_country_report_bangladesh.pdf.

137. Goyal A, Yusuf S. The burden of cardiovascular disease in the Indian subcontinent. Indian J Med Res. 2006;124(3):235-44.

138. Ramaraj RC, P. Cardiovascular Risk in South Asians. Postgraduate Medical Journal. 2008;84(996):518-23.

139. Zaman MM, Bhuiyan MR, Karim MN, Moniruzzaman, Rahman MM, Akanda AW, et al. Clustering of non-communicable diseases risk factors in Bangladeshi adults: An analysis of STEPS survey 2013. BMC Public Health. 2015;15(659).

140. Zaman MM, Choudhury SR, Ahmed J, Talukder MH, Rahman AS. Blood glucose and cholesterol levels in adult population of Bangladesh: results from STEPS 2006 survey. Indian Heart Journal. 2016;68(1):52-6.

141. Fatema K, Zwar NA, Milton AH, Ali L, Rahman B. Prevalence of risk factors for cardiovascular diseases in bangladesh: a systematic review and meta-analysis. PloS one. 2016;11(8):e0160180.

142. Streatfield PK, ZA. Population challenges for Bangladesh in the coming decades. Journal of Health, Population, and Nutrition 2008;26(3):261-72.

143. Report on Sample Vital Registration System 2010. Dhaka: Bangladesh Bureau of Statistics (BBS), Ministry of Planning, Government of the People's Republic of Bangladesh; 2011.

144. Misra AG, OP. Migration and its impact on adiposity and type 2 diabetes. Nutrition. 2007;23:696-708.

145. Daar AS, PA; Leah, Persad; et al. Grand challenges in chronic non-communicable diseases. Nature. 2007;450:494-6.

146. Lyngdoh T, Kinra S, Shlomo YB, Reddy KS, Prabhakaran D, Smith GD, et al. Sib-recruitment for studying migration and its impact on obesity and diabetes. Emerging Themes in Epidemiology 2006;3(2).

147. McKay LM, S; Ellaway, A. Migration and health: a review of the international literature. . Glasgow: Medical Research Council, Social & Public Health Sciences Unit, University of Glasgow; 2003.

148. Kinra S. Commentary: can conventional migration studies really identify critical age-period effects? International Journal of Epidemiology. 2004;33(6):1226-7.

149. Bangladesh Urban Health Survey 2006. Dhaka: National Institute of Population Research and Training (NIPORT), MEASURE Evaluation, International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B), and Associates for Community and Population Research (ACPR). ; 2008.

150. Addo J, Smeeth L, Leon DA. Hypertension in Sub-Saharan Africa. Hypertension. 2007;50(6):1012-8.

151. Ramachandran A, Mary S, Yamuna A, Murugesan N, Snehalatha C. High prevalence of diabetes and cardiovascular risk factors associated with urbanization in India. Diabetes care. 2008;31(5):893-8.

152. Hussain A, Rahim M, Azad Khan A, Ali S, Vaaler S. Type 2 diabetes in rural and urban population: diverse prevalence and associated risk factors in Bangladesh. Diabetic Medicine. 2005;22(7):931-6.

153. Ro A. The longer you stay, the worse your health? A critical review of the negative acculturation theory among Asian immigrants. International Journal of Environmental Research and Public Health. 2014;11:8038-57.

154. Salanta T, Lauderdaleb DS. Measuring culture: a critical review of acculturation and health in Asian immigrant populations. Social Science and Medicine. 2003;57:71-90.

155. Koya DL, Egede LE. Association between length of residence and cardiovascular disease risk factors among an ethnically diverse group of United States immigrants. Society of General Internal Medicine. 2007;22:841-6.

156. Hayes L, White M, Unwin N, Bhopal R, Fischbacher C, Harland J, et al. Patterns of physical activity and relationship with risk markers for cardiovascular disease and diabetes in Indian, Pakistani, Bangladeshi and European adults in a UK population. Journal of Public Health Medicine. 2002;24(3):170-8.

157. Steptoe A, Marmot M. Socioeconomic status and coronary heart disease: a psychological perspective. In: Linda J, editor. Aging, health and public policy: demographic and economic perspectives. 30. New York: Population Council; 2004.

158. Bhopal R, Hayes L, White M, Unwin N, Harland J, Ayis S. Ethnic and socio-economic inequalities in coronary heart disease, diabetes and risk factors in Europeans and South Asians. Journal of Public Health Medicine. 2002;24:95-105.

159. Williams R, Wright W, Hunt K. Social class and health: the puzzling counter-example of British South Asians. Social Science Medicine. 1998;47:1277-88.

160. Yusuf S, Reddy S, Ounpuu S, Anand S. Global burden of cardiovascular diseases Part I: general considerations, the epidemiologic transition, risk factors and impact of urbanization. Circulation. 2001;104(22):2746-52.

161. Hilmers A, Bernabé-Ortiz A, Gilman RH, McDermott AY, Smeeth L, Miranda JJ. Rural-to-Urban Migration: Socioeconomic Status But Not Acculturation was Associated with Overweight/Obesity Risk. Journal of immigrant and minority health. 2016;18(3):644-51.

162. Gupta V, Yadav K, Anand K. Patterns of tobacco use across rural, urban, and urbanslum populations in a North Indian community. Indian Journal of Community Medicine. 2010;35(2):245-51.

163. Yadav K, Krishnan A. Changing patterns of diet, physical activity and obesity among urban, rural and slum populations in north India. Obesity Reviews. 2008;9:400-8.

164. National Institute of Population Research and Training (NIPORT), Associates for Community and Population Research (ACPR) in Bangladesh, University of North Carolina in Chapel Hill NC, USA, . Bangladesh Urban Health Survey 2006.

165. Angeles G, Al-Sabir A, Lance P, Buckner B, Streatfield P, Karar Z. Bangladesh Urban Health Survey (UHS) 2006. 2013.

166. Angeles G, Lance P, Barden-O'Fallon J, Islam N, Mahbub A, Nazem NI. The 2005 census and mapping of slums in Bangladesh: design, select results and application. International Journal of Health Geographics. 2009;8(1):32.

167. Panday P. Local Government System in Bangladesh: How Far is it Decentralised? Lexlocalis- Journal of Local Self- Government. 2011;29.

168. Bangladesh Bureau of Statistics. Bangladesh Population & Housing Census 2011: Urban Area Report. Bangladesh: Bangladesh Bureau of Statistics, Statistics and Informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh; 2014.

169. Barba C, Cavalli-Sforza T, Cutter J, Darnton-Hill I. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. The lancet. 2004;363(9403):157.

170. World Health Organization. Definition and diagnosis of diabetes mellitus and intermediate hyperglycemia: report of a WHO/IDF consultation. World Hearth Org. 2006.

171. Beusenberg M, Orley JH, Organization WH. A User's guide to the self reporting questionnaire (SRQ. 1994.

172. Harpham T, Reichenheim M, Oser R, Thomas E, Hamid N, Jaswal S, et al. Measuring mental health in a cost-effective manner. Health policy and planning. 2003;18(3):344-9.

173. Fahey N, Soni A, Desai R, Samrau K, Halim N, Phatak A, et al. Self-Reporting Questionnaire (SRQ-20) as Common Mental Disorders (CMD) Screening Tool Among Women in Low-Income Rural Communities of India2014.

174. Islam N, Saleheen M. Rural-urban linkage and migration issue in Bangladesh Dhaka, Bangladesh: Centre for Urban Studies (CUS); 2006.

175. Haider SKU. Factors of migration on urban Bangladesh: an empirical study of poor migrants in Rajshahi city. Pakistan Journal of Social Sciences 2010;30(2):307-23.

176. Haque ME, Islam MM. Rural to urban migration and household living conditions in Bangladesh. Dhaka University Journal of Science. 2012;60(2):253-7.

177. Islam MM, Gagnon AJ. Use of reproductive health care services among urban migrant women in Bangladesh. BMC women's health. 2016;16(1):15.

178. Miranda JJ, Gilman RH, Garcia HH, Smeeth L. The effect on cardiovascular risk factors of migration from rural to urban areas in Peru: PERU MIGRANT Study. BMC Cardiovascular Disorders. 2009;9(23).

179. Psaltopoulou T, Hatzis G, Papageorgiou N, Androulakis E, Briasoulis A, Tousoulis D. Socioeconomic status and risk factors for cardiovascular disease: impact of dietary mediators. Hellenic Journal of Cardiology. 2017.

180. Sovio U, Giambartolomei C, Kinra S, Bowen L, Dudbridge F, Nitsch D, et al. Early and current socio-economic position and cardiometabolic risk factors in the Indian Migration Study. European Journal of Preventive Cardiology. 2012;20(5):844-53.

181. Pollitt RA, Rose KM, Kaufman JS. Evaluating the evidence for models of life course socioeconomic factors and cardiovascular outcomes: a systematic review. BMC public health. 2005;5(1):7.

182. Quispe R, Benziger CP, Bazo-Alvarez JC, Howe LD, Checkley W, Gilman RH, et al. The relationship between socioeconomic status and CV risk factors: the CRONICAS cohort study of Peruvian adults. Global heart. 2016;11(1):121-30. e2.

183. M G Marmot, M Kogevinas a, Elston MA. Social/Economic Status and Disease. Annual Review of Public Health. 1987;8(1):111-35.

184. Ali MK, Bhaskarapillai B, Shivashankar R, Mohan D, Fatmi ZA, Pradeepa R, et al. Socioeconomic status and cardiovascular risk in urban South Asia: the CARRS Study. European journal of preventive cardiology. 2016;23(4):408-19.

185. Samuel P, Antonisamy B, Raghupathy P, Richard J, Fall CH. Socio-economic status and cardiovascular risk factors in rural and urban areas of Vellore, Tamilnadu, South India. International journal of epidemiology. 2012;41(5):1315-27.

186. Marmot MG, Adelstein AM, Robinson N, Rose GA. Changing social-class distribution of heart disease. Br Med J. 1978;2(6145):1109-12.

187. Biswas T, Islam MS, Linton N, Rawal LB. Socio-economic inequality of chronic non-communicable diseases in Bangladesh. PloS one. 2016;11(11):e0167140.

188. World Health Organization. Non-communicable disease risk factor survey Bangladesh 2010. Bangladesh: World Health Organization (WHO); 2011.

189. Kinra S, Bowen LJ, Lyngdoh T, Prabhakaran D, Reddy KS, Ramakrishnan L, et al. Sociodemographic patterning of non-communicable disease risk factors in rural India: a cross sectional study. Bmj. 2010;341:c4974.

190. Resosudarmo BP, Suryahadi A, Purnagunawan R, Yumna A, Yusrina A. The socio-economic and health status of rural-urban migrants in Indonesia. East Asian Bureau of Economic Research; 2009.

191. Forsdahl A. Living conditions in childhood and subsequent development of risk factors for arteriosclerotic heart disease. The cardiovascular survey in Finnmark 1974-75. Journal of Epidemiology & Community Health. 1978;32(1):34-7.

192. Lu Y. Rural-urban migration and health: Evidence from longitudinal data in Indonesia. Social science & medicine. 2010;70(3):412-9.

193. Khan MM, Krämer A. Factors associated with being underweight, overweight and obese among ever-married non-pregnant urban women in Bangladesh. Singapore medical journal. 2009;50(8):804.

194. Szklarska A, Lipowicz A, Lopuszanska M, Bielicki T, Koziel S. Biological condition of adult migrants and nonmigrants in Wrocław, Poland. American Journal of Human Biology. 2008;20(2):139-45.

195. Islam SMS, Mainuddin A, Islam MS, Karim MA, Mou SZ, Arefin S, et al. Prevalence of risk factors for hypertension: A cross-sectional study in an urban area of Bangladesh. Global cardiology science & practice. 2015;2015(4):43.

196. Biswas T, Islam A, Rawal LB, Islam SMS. Increasing prevalence of diabetes in Bangladesh: a scoping review. Public Health. 2016;138:4-11.

197. Organization WH. Screening for type 2 diabetes: report of a World Health Organization and International Diabetes Federation meeting. 2003.

198. Tirimacco R, Tideman P, Dunbar J, Simpson P, Philpot B, Laatikainen T, et al. Should capillary blood glucose measurements be used in population surveys? International journal of diabetes mellitus. 2010;2(1):24-7.

199. Lindgärde F, Ercilla MB, Correa LR, Ahrén B. Body adiposity, insulin, and leptin in subgroups of Peruvian Amerindians. High altitude medicine & biology. 2004;5(1):27-31.

200. World Health Organization. Global Adult Tobacco Survey: Bangladesh Report 2009. Bangladesh; 2009.

201. Taype-Rondan A, Bernabe-Ortiz A, Alvarado GF, Gilman RH, Smeeth L, Miranda JJ. Smoking and heavy drinking patterns in rural, urban and rural-to-urban migrants: the PERU MIGRANT Study. BMC public health. 2017;17(1):165.

202. Allender S, Lacey B, Webster P, Rayner M, Deepa M, Scarborough P, et al. Level of urbanization and noncommunicable disease risk factors in Tamil Nadu, India. Bulletin of the World Health Organization. 2010;88(4):297-304.

203. Yang T, Wu J, Rockett I, Abdullah A, Beard J, Ye J. Smoking patterns among Chinese rural–urban migrant workers. Public health. 2009;123(11):743-9.

204. Yang X. Rural–urban migration and mental and sexual health: A case study in Southwestern China. Health Psychology and Behavioral Medicine: An Open Access Journal. 2014;2(1):1-15.

205. Hossain MD, Ahmed HU, Chowdhury WA, Niessen LW, Alam DS. Mental disorders in Bangladesh: a systematic review. BMC psychiatry. 2014;14(1):216.

206. Nuri NN, Sarker M, Ahmed HU, Hossain MD, Dureab F, Agbozo F, et al. Overall care-seeking pattern and gender disparity at a specialized mental hospital in Bangladesh. Materia Socio-Medica. 2019;31(1):35-9.

207. Loret de Mola C, Stanojevic S, Ruiz P, Gilman RH, Smeeth L, Miranda JJ. The effect of rural-to-urban migration on social capital and common mental disorders: PERU MIGRANT study. Social Psychiatry and Psychiatric Epidemiology. 2012;47:967-73.

208. Li L, Wang H-m, Ye X-j, Jiang M-m, Lou Q-y, Hesketh T. The mental health status of Chinese rural–urban migrant workers. Social Psychiatry and Psychiatric Epidemiology. 2007;42(9):716-22.

209. Firdaus G. Mental well-being of migrants in urban center of India: Analyzing the role of social environment. Indian Journal of Psychiatry. 2017;59(2):164.

210. Rivera B, Casal B, Currais L. Length of stay and mental health of the immigrant population in Spain: evidence of the healthy immigrant effect. Applied Economics. 2015;47(19):1972-82.

211. Dewan A, Corner R. Dhaka megacity: Geospatial perspectives on urbanisation, environment and health: Springer Science & Business Media; 2013.

212. Saquib N, Khanam MA, Saquib J, Anand S, Chertow GM, Barry M, et al. High prevalence of type 2 diabetes among the urban middle class in Bangladesh. BMC public health. 2013;13(1):1032.

213. Snyder RE, Rajan JV, Costa F, Lima HC, Calcagno JI, Couto RD, et al. Differences in the prevalence of non-communicable disease between slum dwellers and the general population in a large urban area in Brazil. Tropical Medicine and Infectious Disease. 2017;2(3):47.

214. Gupta V, Yadav K, Anand K. Patterns of tobacco use across rural, urban, and urban-slum populations in a north Indian community. Indian journal of community medicine: official publication of Indian Association of Preventive & Social Medicine. 2010;35(2):245.

215. Singh R, Mukherjee M, Kumar R, Singh R, Pal R. Study of risk factors of coronary heart disease in urban slums of Patna. Nepal Journal of Epidemiology. 2012;2(3):205-12.

216. Joshi MD, Ayah R, Njau EK, Wanjiru R, Kayima JK, Njeru EK, et al. Prevalence of hypertension and associated cardiovascular risk factors in an urban slum in Nairobi, Kenya: a population-based survey. BMC public health. 2014;14(1):1177.

217. Rawal LB, Biswas T, Khandker NN, Saha SR, Chowdhury MMB, Khan ANS, et al. Non-communicable disease (NCD) risk factors and diabetes among adults living in slum areas of Dhaka, Bangladesh. PloS one. 2017;12(10):e0184967.

218. Khan M, Hossain M, Kraemer A. Are rural–urban migrants living in urban slums more vulnerable in terms of housing, health knowledge, smoking, mental health and general health? International Journal of Social Welfare. 2014;23(4):373-83.

219. Chowdhury MAB, Uddin MJ, Khan HM, Haque MR. Type 2 diabetes and its correlates among adults in Bangladesh: a population based study. BMC public health. 2015;15(1):1070.

220. Chowdhury MAB, Uddin MJ, Haque MR, Ibrahimou B. Hypertension among adults in Bangladesh: evidence from a national cross-sectional survey. BMC cardiovascular disorders. 2016;16(1):22.

221. Hossain S, editor Social characteristics of a megacity: a case of Dhaka City, Bangladesh. Proc TASA 2006 Conf, Perth, Australia; 2006.

222. Capital Development Authority of Bangladesh. Dhaka Structure Plan (2016-35). Dhaka: Capital Development Authority of Bangladesh.

223. Bangladesh Demographic and Health Survey 2011. Bangladesh: National Institute of Population Research and Training, Mitra and Associates, MEASURE DHS; 2013.

224. Lee I-M, Shiroma EJ, Lobelo F, Puska P, Blair SN, Katzmarzyk PT. Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. Lancet. 2012;380:219-29.

225. Das P, Horton R. Rethinking our approach to physical activity. Lancet. 2012;380:189-90.

226. Hallal PC, Bauman A, Heath GW, Kohl HW, Lee I-M, Pratt M. Physical activity: more of the same is not enough. Lancet. 2012;380.

227. Ding D, Lawson KD, Kolbe-Alexander TL, Finkelstein EA, Katzmarzyk PT, Mechelen Wv, et al. The economic burden of physical inactivity: a global analysis of major non-communicable diseases. Lancet. 2016;388:1311-24.

228. Macfarlane D, Chan A, Cerin E. Examining the validity and reliability of the Chinese version of the International Physical Activity Questionnaire, long form (IPAQ-LC). Public Health Nutrition. 2010;14(3):443-50.

229. Cleland CL, Hunte rRF, Kee F, Cupples ME, Sallis JF, Tully MA. Validity of the Global Physical Activity Questionnaire (GPAQ) in assessing levels and change in moderate-vigorous physical activity and sedentary behaviour. BMC Public Health. 2014;14(1255).

230. Bauman A, Craig CL. The place of physical activity in the WHO Global Strategy on Diet and physical activity. International Journal of Behavioral Nutrition and Physical Activity. 2005;2(10).

231. World Health Organization. WHO STEPS Surveillance Manual: the WHO STEPwise Approach to Chronic Disease Risk Factor Surveillance. Geneva, Switzerland: World Health Organization; 2005.

232. Bonnita R, de courten M, Dwyer T, Jamrozik K, Winkelmann R. Surveillance of risk factors for non-communicable diseases: the WHO STEP wise approach. Summary. Geneva: World Health Organization; 2001.

233. World Health Organization. Global Strategy on Diet, Physical Activity and Health. Geneva, Switzerland:: World Health Organization; 2004.

234. Armstrong T, Bull FC. Development of the World Health Organization Global Physical Activity Questionnaire (GPAQ). Journal of Public Health. 2006;14(2):66-70.

235. Bull FC, Maslin TS, Armstrong T. Global Physical Activity Questionnaire (GPAQ): nine country reliability and validity study. Journal of Physical Activity and Health. 2009;6:790-804.

236. Moniruzzaman M, Zaman MM, Islam M, Ahsan H, Kabir H, Yasmin R. Physical activity levels in Bangladeshi adults: results from STEPS survey 2010. Public Health Nutrition. 2016.

237. Anjana RM, Pradeepa R, Das AK, Deepa M, Bhansali A, Joshi SR, et al. Physical activity and inactivity patterns in India–results from the ICMR-INDIAB study (Phase-1)[ICMR-INDIAB-5]. International Journal of Behavioral Nutrition and Physical Activity. 2014;11(1):1.

238. Assah F, Mbanya JC, Ekelund U, Wareham N, Brage S. Patterns and correlates of objectively measured free-living physical activity in adults in rural and urban Cameroon. Journal of epidemiology and community health. 2015:jech-2014-205154.

239. Padrão P, Damasceno A, Silva-Matos C, Prista A, Lunet N. Physical activity patterns in Mozambique: urban/rural differences during epidemiological transition. Preventive medicine. 2012;55(5):444-9.

240. Akter S, Rahman MM, Abe SK, Sultana P. Prevalence of diabetes and prediabetes and their risk factors among Bangladeshi adults: a nationwide survey. Bulletin of the World Health Organization. 2014;92:204-13A.

241. Hussain A, Rahim M, Khan AA, Ali S, Vaaler S. Type 2 diabetes in rural and urban population: diverse prevalence and associated risk factors in Bangladesh. Diabetic Medicine. 2005;22:931-36.

242. Lavrakas P. Last-Birthday Selection. Encyclopedia of Survey Research Methods. 2008.

243. World Health Organization. Global Physical Activity Questionnaire (GPAQ) Analysis Guide , [Available from: http://www.who.int/chp/steps/resources/GPAQ_Analysis_Guide.pdf.

244. Shephard RJ, Tudor-Locke C. The Objective Monitoring of Physical Activity: Contributions of Accelerometry to Epidemiology, Exercise Science and Rehabilitation. Switzerland: Springer International Publishing; 2016.

245. Trost SG, McIver KL, Pate RR. Conducting accelerometer-based activity assessments in field-based research. Med Sci Sports Exerc. 2005;37(11 Suppl):S531-43.

246. Atkin AJ, Gorely T, Clemes SA, Yates T, Edwardson C, Brage S, et al. Methods of measurement in epidemiology: sedentary behaviour. International Journal of Epidemiology 2012;41:1460-71.

247. Freedson PS, Melanson E, Sirard J. Calibration of the computer science and applications, Inc. accelerometer. Medicine and Science in Sports and Exercise. 1998;30(5):777-81.

248. Landis JR, Koch GG. The Measurement of Observer Agreement for Categorical Data. Biometrics. 1977;33(1):159-74.

249. Herrmann SD, Heumann KJ, Ananian CAD, Ainsworth BE. Validity and Reliability of the Global Physical Activity Questionnaire (GPAQ). Measurement in Physical Education and Exercise Science. 2013;17(3):221-35.

250. Chu AH, Ng SH, Koh D, Muller-Riemenschneider F. Reliability and validity of the self-and-interviewer-administered versions of the Global Physical Activity Questionnaire (GPAQ). Plos One. 2015;10(9).

251. Trinh O, Nguyen N, van der Ploeg H, Dibley M, Bauman A. Test–retest repeatability and relative validity of the Global Physical Activity Questionnaire in a developing country context. Journal of Physical Activity & Health. 2009;6(Suppl. 1):S46-S53.

252. Aguilar-Farias N, Zamora jL. Is a single question of the Global Physical Activity Questionnaire (GPAQ) valid for measuring sedentary behaviour in the Chilean population? Journal of Sports Sciences. 2016.

253. Hoos T, Espinoza N, Marshall S, Arredondo EM. Validity of the Global Physical Activity Questionnaire (GPAQ) in adult Latinas. Jounal of Physical Activity and Heath. 2012;9(5):698-705.

254. Alkahtani SA. Convergent validity: agreement between accelerometry and the Global Physical Activity Questionnaire in college-age Saudi men. BMC Research Notes. 2016;9(436).

255. Thuy AB, Blizzard L, Schmidt M, Luc PH, Magnussen C, Dwyer T. Reliability and validity of the Global Physical Activity Questionnaire in Vietnam. Jounal of Physical Activity and Heath. 2010;7:410-8.

256. Craig CL, Marshall AL, Sjostrom M, Bauman A, Booth ML, Ainsworth BE, et al. International Physical Activity Questionnaire: 12-Country Reliability and Validity. Medicine and Science in Sports and Exercise. 2003;35(8):1381-95.

257. Kelly P, Fitzsimons C, Baker G. Should we reframe how we think about physical activity and sedentary behaviour measurement? Validity and reliability reconsidered. International Journal of Behavioral Nutrition and Physical Activity. 2016;13(32).

258. Herman HB, Børtnes I, Hildebrand M, Holme I, Kolle E, SA A. Validity of the ActiGraph GT1M during walking and cycling. Journal of Sports Sciences. 2014;32(6):510-6.

259. Welk G, McClain J, Eisenmann J, Wicke E. Field validation of the MTI Actigraph and bodymedia armband monitor using the IDDEE monitor. Obesity. 2007;15(4):918-28.

260. Khanam M, Ahmed S. Agricultural Calendar (Banglapedia National Encyclopedia of Bangladesh) Bangladesh: Asiatic Society of Bangladesh; 2012 [updated 03.09.2014. Available from: http://en.banglapedia.org/index.php?title=Agricultural_Calendar.

261. Ng N, Hakimi M, Van Minh H, Juvekar S, Razzaque A, Ashraf A, et al. Prevalence of physical inactivity in nine rural INDEPTH Health and Demographic Surveillance Systems in five Asian countries. Global Health Action. 2009;2.

262. Lee PH, McDowell I, Leung GM, Lam T, Stewart SM. Performance of the international physical activity questionnaire (short form) in subgroups of the Hong

Kong chinese population. International Journal of Behavioral Nutrition and Physical Activity. 2011;8(81).

263. Oyeyem AL, Bello UM, Philemon ST, Aliyu HN, Majidadi RW, Oyeyemi AY. Examining the reliability and validity of a modified version of the International Physical Activity Questionnaire, long form (IPAQ-LF) in Nigeria: a cross-sectional study. BMJ Open. 2014;4(e005820).

264. Ainsworth BE, Haskell WL, Whitt MC, L IM, Swartz AM, Strath SJ, et al. Compendium of Physical Activities: an update of activity codes and MET intensities. Medicine and Science in Sports and Exercise. 2000;32(9):S498-504.

265. Clemes S, David B, Zhao Y, Han X, Brown W. Validity of two self-report measures of sitting time. Jounal of Physical Activity and Heath. 2012;9:533-9.

266. Atkin A, Gorely T, Clemes S, Yates T, Edwardson C, Brage S, et al. Methods of measurement in epidemiology: sedentary behaviour. International Journal of Epidemiology. 2012;41:1460-71.

267. Plasqui G, Westerterp K. Physical activity assessment with accelerometers: an evaluation against doubly labelled water. Obesity. 2007;15:2371-9.

268. Haskell W. Physical activity by self-report: a brief history and future issues. Jounal of Physical Activity and Heath. 2012;9(Suppl 1):S5-S10.

269. Adams S, Matthews C, Ebbeling C, Moore C, Cunningham J, Fulton J, et al. The effect of social desirability and social approval on selfreports of physical activity. American Journal of Epidemiology. 2005;161:389-98.

270. Moniruzzaman M, Ahmed MM, Zaman MM. Physical activity levels and associated socio-demographic factors in Bangladeshi adults: a cross-sectional study. BMC Public Health. 2017;17(1):59.

271. Moniruzzaman M, Zaman MM, Islalm M, Ahasan H, Kabir H, Yasmin R. Physical activity levels in Bangladeshi adults: results from STEPS survey 2010. Public Health. 2016;137:131-8.

272. Tucker P, Gilliland J. The effect of season and weather on physical activity: a systematic review. Public health. 2007;121(12):909-22.

273. Kriska AM, Caspersen CJ. Introduction to a collection of physical activity questionnaires. Medicine& Science in Sports & Exercise. 1997;29(6):5-9.

274. Bauman A, Bull FC, Chey T, Craig CL, Ainsworth BE, Sallis JF, et al. The international prevalence study on physical activity: results from 20 countries. International Journal of Behavioral Nutrition and Physical Activity. 2009;6(1).

275. Khanam M, Ahmed S. Season (Banglapedia National Encyclopecia of Bangladesh) Bangladesh: Asiatic Society of Bangladesh; 2012 [updated 06.07.2014. Second:[Available from: http://en.banglapedia.org/index.php?title=Season.

276. Mumu SJ, Ali L, Barnett A, Merom D. Validity of the global physical activity questionnaire (GPAQ) in Bangladesh. BMC public health. 2017;17(1):650.

277. Taylor HL, Jacobs DR, Shucker B, Knudsen J, Leon AS, DeBacker G. A questionnaire for the assessment of leisure-time physical activity. Journal of Chronic Disease. 1978;31:741-55.

278. Richardson MT, Leon AS, Jacobs DR, Ainsworth B, Serfass R. Comprehensive evaluation of the Minnesota Leisure Time Physical Activity questionnaire. Journal of Clinical Epidemiology. 1994;47(3):271-81.

279. Climate Thakurgaon [Available from: https://en.climate-data.org/asia/bangladesh/rangpur-division/thakurgaon-56259/.

280. Chan CB, Ryan DA. Assessing the effects of weather conditions on physical activity participation using objective measures. International journal of environmental research and public health. 2009;6(10):2639-54.

281. Pivarnik JM, Reeves MJ, Rafferty AP. Seasonal variation in adult leisure-time physical activity. Medicine and Science in Sports and Exercise. 2003;35(6):1004-8.

282. Badland HM, Christian H, Giles-Corti B, Knuiman M. Seasonality in physical activity: Should this be a concern in all settings? Health & place. 2011;17(5):1084-9.

283. Uddin R, Burton NW, Khan A. Perceived environmental barriers to physical activity in young adults in Dhaka city, Bangladesh - does gender matter? Int Health. 2018;10:40-6.

284. Friedenreich CM, Courneya KS, Neilson HK, Matthews CE, Willis G, Irwin M, et al. Reliability and validity of the past year total physical activity questionnaire. American journal of epidemiology. 2006;163(10):959-70.

285. Wareham NJ, Jakes RW, Rennie KL, Mitchell J, Hennings S, Day NE. Validity and repeatability of the EPIC-Norfolk physical activity questionnaire. International journal of epidemiology. 2002;31(1):168-74.

286. Anjana RM, Sudha V, Lakshmipriya N, Subhashini S, Pradeepa R, Geetha L, et al. Reliability and validity of a new physical activity questionnaire for India. International Journal of Behavioral Nutrition and Physical Activity. 2015;12(1):40.

287. Hagströmer M, Oja P, Sjöström M. The International Physical Activity Questionnaire (IPAQ): a study of concurrent and construct validity. Public health nutrition. 2006;9(06):755-62.

288. Oyeyemi AL, Umar M, Oguche F, Aliyu SU, Oyeyemi AY. Accelerometer-determined physical activity and its comparison with the International Physical Activity Questionnaire in a sample of Nigerian adults. PloS one. 2014;9(1):e87233.

289. Merom D, Sinnreich R, Aboudi V, Kark JD, Nassar H. Lifestyle physical activity among urban Palestinians and Israelis: a cross-sectional comparison in the Palestinian-Israeli Jerusalem risk factor study. BMC public health. 2012;12(1):90.

290. Mealing NM, Bowles HR, Merom D, Bauman A. Impact of scoring algorithm on physical activity prevalence estimates in Australian adults. Journal of Science and Medicine in Sport. 2011;14(1):27-32.

291. Brownson RC, Jones DA, Pratt M, Blanton C, Heath GW. Measuring physical activity with the behavioral risk factor surveillance system. Medicine and Science in Sports and Exercise. 2000;32(11):1913-8.

292. Reis RS, Salvo D, Ogilvie D, Lambert EV, Goenka S, Brownson RC. Scaling up physical activity interventions worldwide: stepping up to larger and smarter approaches to get people moving. The Lancet. 2016;388(10051):1337-48.

293. World Health Organization. ACTIVE: a technical package for increasing physical activity. World Health Organization; 2018.

294. Deaton C, Froelicher ES, Wu LH, Ho C, Shishani K, Jaarsma T. The global burden of cardiovascular disease. Journal of Cardiovascular Nursing. 2011;26(45):S5-S14.

295. World Health Organization. Cardiovascular disease 2018 [Available from: http://www.who.int/cardiovascular_diseases/en/.

296. Chowdhury MZI, Haque MA, Farhana Z, Anik AM, Chowdhury AH, Haque SM, et al. Prevalence of cardiovascular disease among Bangladeshi adult population: a systematic review and meta-analysis of the studies. Vascular health and risk management. 2018;14:165.

297. Diet [Available from: http://www.world-heart-federation.org/cardiovascular-health/cardiovascular-disease-risk-factors/diet/.

298. Clifton P. Diet and cardiovascular disease: dietary patterns, foods and nutrients. Nutrition and Dietetics. 2013;70:170-1.

299. Sauvageot N, Guillaume M, Albert A. Validation of the food frequency questionnaire used to assess the association between dietary habits and cardiovascular risk factors in the NESCAV study. Journal of Food Science. 2013;3(3).

300. Bhupathiraju SN, Tucker KL. Coronary heart disease prevention: nutrients, foods, and dietary patterns. Clinica chimica acta. 2011;412(17-18):1493-514.

301. Bowen KJ, Sullivan VK, Kris-Etherton PM, Petersen KS. Nutrition and cardiovascular disease—an update. Current atherosclerosis reports. 2018;20(2):8.

302. Schroder HC, MI; Marrugat, J; Vila, J; Pena, A; Alcantara, M; Masia R. Use of three-day estimated food record, a 72-hour recall and a food-frequency questionnaire for dietary assessment in a Mediterranean Spanish population. Clinical nutrition. 2001;20(5):429-37.

303. Sauvageot NA, Ala'a; Albert, Adelin; Guillaume, Michele. Use of food frequency questionnaire to assess relationships between dietary habits and cardiovascular risk factors in NESCAV study: validation with biomarkers. Nutrition Journal. 2013;12(143).

304. Willet W. Nutritional Epidemiology. 3rd ed. New York: Oxford University Press; 2013.

305. Lee RD, Nieman DC. Nutritional Assessment. 6th ed. New York: McGraw Hill; 2013.

306. Sampson L. Food frequency questionnaire as a research instrument. Clinical nutrition. 1985;4:171-8.

307. Subar AF, Thompson FE, Kipnis V, Midthune D, Hurwitz P, McNutt S, et al. Comparative Validation of the Block, Willett, and National Cancer Institute Food

Frequency Questionnaires. American Journal of Epidemiology. 2001;154(12):1089-99.

308. Chen YA, Habibul; Parvez, Faruque; Howe, Geoffrey R Validity of a food-frequency questionnaire for a large prospective cohort study in Bangladesh. British Journal of Nutrition. 2004;92:851-9.

309. Bowen L, Bharathi AV, Kinra S, DeStavola B, Ness A, Ebrahim S. Development and evaluation of a semi-quantitative food frequency questionnaire for use in urban and rural India. Asia Pacific Journal of Nutrition. 2012;21(3):355-60.

310. Cade J, Burley V, Warm D, Thompson L, Margetts B. Food-frequency questionnaires: a review of their design, validation and utilisation. Nutrition Research Reviews. 2004;17:5-22.

311. Cade J, Thompson R, Burley V, Warm D. Development, validation and utilisation of food-frequency questionnaires- a review. Public Health Nutrition. 2002;5(4):567-87.

312. Shaheen NR, Abu Torab MA; Mohiduzzaman,Md; Banu,Cadi Parvin; Bari, Md. Latiful; Tukun,Avonti Basak; Mannan, MA; Bhattacharjee, Lalita; Stadlmayr, Barbara Food Composition Table for Bangladesh. 1st ed. Dhaka, Bangladesh: Intergraphic Limited; 2013.

313. Islam SN, Khan MNI, Akhtaruzzaman M. A food composition database for Bangladesh with special reference to selected ethnic foods. Dhaka: Institute of Nutrition and Food Sciences University of Dhaka. 2010.

314. Ahmed K, Malek MA, Jahan K., Salamatullah Q, SMK A. Deshiyo Khaddyodrobbeyer Pushtiman (DKP) (in Bangla). Institute of Nutrition and Food Science (INFS), University of Dhaka, Dhaka-1000, Bangladesh; 1992.

315. Darnton-Hill I, Hassan N, Karim R, Duthie M. Tables of nutrient composition of Bangladesh foods. Helen Keller International (HKI) Bangladesh; 1988.

316. United States Department of Agriculture. USDA Food Composition Databases [Available from: https://ndb.nal.usda.gov/ndb/.

317. Longvah T, Ananthan R, Bhaskarachary K, Venkaiah K. Indian food composition tables. National Institute of Nutrition, Indian Council of Medical Research, Department of Health Research, Ministry of Health and Family Welfare, Government of India (505 pp). 2017.

318. Willett WC, Sampson L, Stampfer MJ, Rosner B, Bain C, Witschi J, et al. Reproducibility and validity of a semiquantitative food frequency questionnaire. American journal of epidemiology. 1985;122(1):51-65.

319. Liu L, Wang PP, Roebothan B, Ryan A, Tucker CS, Colbourne J, et al. Assessing the validity of a self-administered food-frequency questionnaire (FFQ) in the adult population of Newfoundland and Labrador, Canada. Nutrition journal. 2013;12(1):49.

320. Saleh F, Mumu S, Ara F, Begum H, Ali L. Knowledge and self-care practices regarding diabetes among newly diagnosed type 2 diabetics in Bangladesh: a cross-sectional study. BMC Public Health. 2012;12(1):1112.

321. Lin P-I, Bromage S, Mostofa M, Allen J, Oken E, Kile M, et al. Validation of a Dish-Based Semiquantitative Food Questionnaire in Rural Bangladesh. Nutrients. 2017;9(1):49.

322. Rodríguez MM, Méndez H, Torún B, Schroeder D, Stein AD. Validation of a semi-quantitative food-frequency questionnaire for use among adults in Guatemala. Public health nutrition. 2002;5(5):691-8.

323. Sudha V, Radhika G, Sathya R, Ganesan A, Mohan V. Reproducibility and validity of an interviewer-administered semi-quantitative food frequency questionnaire to assess dietary intake of urban adults in southern India. International journal of food sciences and nutrition. 2006;57(7-8):481-93.

324. Willett W. Nutritional epidemiology: Oxford University Press; 2012.

325. Jaceldo-Siegl K, Knutsen SF, Sabaté J, Beeson WL, Chan J, Herring RP, et al. Validation of nutrient intake using an FFQ and repeated 24 h recalls in black and white subjects of the Adventist Health Study-2 (AHS-2). Public health nutrition. 2010;13(6):812-9.

326. Krebs-Smith SM, Heimendinger J, Subar AF, Patterson BH, Pivonka E. Using food frequency questionnaires to estimate fruit and vegetable intake: association between the number of questions and total intakes. Journal of Nutrition Education. 1995;27(2):80-5.

327. Araujo MC, Yokoo EM, Pereira RA. Validation and calibration of a semiquantitative food frequency questionnaire designed for adolescents. Journal of the American Dietetic Association. 2010;110(8):1170-7.

328. Bentzen S, Knudsen VK, Christiensen T, Ewers B. Relative validity of a web-based food frequency questionnaire for patients with type 1 and type 2 diabetes in Denmark. Nutrition & diabetes. 2016;6(9):e232.

329. Pirouzpanah S, Taleban F, Mehdipour P, Atri M, Hooshyareh-Rad A, Sabour S. The biomarker-based validity of a food frequency questionnaire to assess the intake status of folate, pyridoxine and cobalamin among Iranian primary breast cancer patients. European journal of clinical nutrition. 2014;68(3):316.

330. Pufulete M, Emery PW, Nelson M, Sanders TA. Validation of a short food frequency questionnaire to assess folate intake. British Journal of Nutrition. 2002;87(4):383-90.

331. Van De Rest O, Durga J, Verhoef P, Melse-Boonstra A, Brants HA. Validation of a food frequency questionnaire to assess folate intake of Dutch elderly people. British journal of nutrition. 2007;98(5):1014-20.

332. Drogan D, Klipstein-Grobusch K, Wans S, Luley C, Boeing H, Dierkes J. Plasma folate as marker of folate status in epidemiological studies: the European Investigation into Cancer and Nutrition (EPIC)-Potsdam study. British Journal of Nutrition. 2004;92(3):489-96.

333. Li Y, Huang T, Zheng Y, Muka T, Troup J, Hu FB. Folic acid supplementation and the risk of cardiovascular diseases: a meta-analysis of randomized controlled trials. Journal of the American Heart Association. 2016;5(8):e003768.

334. Verhaar M, Stroes E, Rabelink T. Folates and cardiovascular disease. Arteriosclerosis, thrombosis, and vascular biology. 2002;22(1):6-13.

335. McLean RM, Farmer VL, Nettleton A, Cameron CM, Cook NR, Campbell NR, et al. Assessment of dietary sodium intake using a food frequency questionnaire and 24-hour urinary sodium excretion: a systematic literature review. The Journal of Clinical Hypertension. 2017;19(12):1214-30.

336. Lapice E, Masulli M, Vaccaro O. Iron deficiency and cardiovascular disease: an updated review of the evidence. Current atherosclerosis reports. 2013;15(10):358.

337. Eftekhari MH, Mozaffari-Khosravi H, Shidfar F, Zamani A. Relation between body iron status and cardiovascular risk factors in patients with cardiovascular disease. International journal of preventive medicine. 2013;4(8):911.

338. Judd SE, Tangpricha V. Vitamin D deficiency and risk for cardiovascular disease. The American journal of the medical sciences. 2009;338(1):40-4.

339. Margetts BM, Nelson M. Design concepts in nutritional epidemiology: OUP Oxford; 1997.

340. Nissenen A, Berrios X, Puska P. Community-Based Non-Communicable Diseases Intervention: Lessons from Developed Countries for Developing Ones. Bulletin of the World Health Organization. 2001;79(10):963-70.

341. Wong MC, Wang HH. Rapid emergence of atherosclerosis in Asia: a systematic review of coronary atherosclerotic heart disease epidemiology and implications for prevention and control strategies. Current opinion in lipidology. 2015;26(4):257-69.

342. Medicine Io. Promoting cardiovascular health in the developing world: A critical challenge to achieve global health. Washington: Institute of Medicine (IOM); 2010.

343. Alam J, Alam M, Rahman M, Khan S, Munna G. Unplanned urbanization: Assessment through calculation of environmental degradation index. International Journal of Environmental Science and Technology 2006;3:119-30.

344. Bangladesh Bureau of Statistics. The monthly statistical bulletin- Bangladesh Bangladesh: Bangladesh Bureau of Statistics (BBS), Statistics and Informatics Division (SID), Ministry of Planning, Government of the People’s Republic of Bangladesh 2013.

345. Moniruzzaman. Physical Activity Levels in Bangladesh: Prevalence and correlates among urban and rural adults. Germany: Lap Lambert Academic publishing; 2012.

346. Trinh O, Ngyun N, Dibley M, Phongsavan P, Bauman A. The prevalence and correlates of physical inactivity among adults in Ho Chi Minh City. BMC Public Health. 2008;8(204):1-11.

347. Ku P, Fox K, McKenna J. Prevalence of leisure-time physical activity in Taiwanese adults: Results of four national surveys 2000-2004. Preventive Medicine. 2006;43:45-7.

348. Lim SS, Vos T, Flaxman AD, Danaei G, Shibuya k, Adair-Rohani H. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet. 2012;380:2224-60.

349. Wandela M, Raberga M, Kumarb B, Holmboe-Ottesen G. Changes in food habits after migration among South Asians settled in Oslo: The effect of demographic, socio-economic and integration factors. Appetite. 2008;50:376-85.

350. Ostby T, Welby T, Prior I. Type 2 (non-insulin-dependent) diabetes mellitus, migration and westernisation: the Tokelau Island Migrant Study. Diabetologia 1989;32:585-90.

351. Stanhope J, IA P. The Tokelau island migrant study: prevalence and incidence of diabetes mellitus. New Zealand Medical Journal 1980;92:417-21.

352. He J, Klag MJ, Wu Z, Qian M-C, Chen J-Y, Mo P-S, et al. Effect of Migration and Related Environmental Changes on Serum Lipid Levels in Southwestern Chinese Men. American Journal of Epidemiology. 1996;144(6):839-48.

353. Creber RMM, Smeeth L, Gilman RH, Miranda JJ. Physical activity and cardiovascular risk factors among rural and urban groups and rural-to-urban migrants in Peru: a cross-sectional study. Rev Panam Salud Publica. 2010;28(1).

354. He J, Klag MJ, Whelton PK, Chen J-Y, Mo J-P, Qian M-C, et al. Migration, Blood Pressure Pattern, and Hypertension: The Yi Migrant Study American Journal of Epidemiology. 1991;134(10):1085-101.

355. Bangladesh Bureau of Statistics. Report of the household income & expenditure survey 2010. Bangladesh: Bangladesh Bureau of Statistics, Ministry of Planning, Government of the People's Republic of Bangladesh; 2010.

356. Bangladesh Bureau of Statistics. Community Report: Dhaka Zila, Population and Housing Census 2011. Bangladesh: Bangladesh Bureau of Statistics, Ministry of Planning, Government of the People's Republic of Bangladesh; 2012.

357. Faul F, Erdfelder E, Lang AG, Buchner A. G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behavior Research Methods. 2007;39:175-91.

358. Bangladesh Bureau of Statistics. Community Report: Thakurgaon Zila, Population and Housing Census 2011. Bangladesh: Bangladesh Bureau of Statistics, Ministry of Planning, Government of the People's Republic of Bangladesh; 2012.

359. Kessler RC, Andrews G, Colpe LJ, Hiripi E, Mroczek DK, Normand S-L, et al. Short screening scales to monitor population prevalences and trends in non-specific psychological distress. Psychological medicine. 2002;32(6):959-76.

360. World Health Organization. Prevention of Cardiovascular Disease: Guidelines for assessment and management of cardiovascular risk. Geneva, Switzerland: World Health Organization; 2007.

361. World Health Organization. Waist circumference and waist-hip ratio: report of a WHO expert consultation, Geneva, 8-11 December 2008. 2011.

362. Von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP, et al. The Strengthening the Reporting of Observational Studies in Epidemiology

(STROBE) statement: guidelines for reporting observational studies. PLoS medicine. 2007;4(10):e296.

363. Uddin R, Khan A, Burton NW. Prevalence and sociodemographic patterns of physical activity among Bangladeshi young adults. Journal of Health, Population and Nutrition. 2017;36(1):31.

364. EFROYMSON D, HOSSAIN M. Improving conditions for walking: research and action in Dhaka, Bangladesh. Journeys. 2015;13:49-58.

365. Millett C, Agrawal S, Sullivan R, Vaz M, Kurpad A, Bharathi AV, et al. Associations between Active Travel to Work and Overweight, Hypertension, and Diabetes in India: A Cross-Sectional Study. Plos Medicine. 2013;10(6).

366. Uddin R, Burton NW, Khan A. Perceived environmental barriers to physical activity in young adults in Dhaka City, Bangladesh—does gender matter? International health. 2018;10(1):40-6.

367. Work for a Better Bangladesh Trust. Parks and playgrounds in Dhaka: taking stock and moving forward. Dhaka, Bangladesh: Work for a Better Bangladesh Trust; 2015.

368. Sadika S, Mohd Isa B, Wan Abdul Manan W. A comparison of food consumption pattern in rural and urban areas of Bangladesh between 2005 and 2010. Health and the Environment Journal. 2013;4(1):1-12.

369. Abedi E, Sahari MA. Long-chain polyunsaturated fatty acid sources and evaluation of their nutritional and functional properties. Food science & nutrition. 2014;2(5):443-63.

370. Chakma S, Hoque MS, Alam AN. Identification of food habit of urban and rural people in the Southern District of Bangladesh. 2015.

371. Huque R, Zaman MM, Huq SM, Sinha DN. Smokeless tobacco and public health in Bangladesh. Indian journal of public health. 2017;61(5):18-.

372. Dudeja V, Misra A, Pandey R, Devina G, Kumar G, Vikram N. BMI does not accurately predict overweight in Asian Indians in northern India. British Journal of Nutrition. 2001;86(1):105-12.

373. Wilson A, Renzaho A. Intergenerational differences in acculturation experiences, food beliefs and perceived health risks among refugees from the Horn of Africa in Melbourne, Australia. Public health nutrition. 2015;18(1):176-88.

374. Antiporta DA, Smeeth L, Gilman RH, Miranda JJ. Length of urban residence and obesity among within-country rural-to-urban Andean migrants. Public health nutrition. 2016;19(7):1270-8.

375. Ruiz-Alejos A, Carrillo-Larco RM, Miranda JJ, Anderson CA, Gilman RH, Smeeth L, et al. Addressing the impact of urban exposure on the incidence of type 2 diabetes mellitus: The PERU MIGRANT Study. Scientific reports. 2018;8(1):5512.

376. Everson-Rose SA, Lewis TT. Psychosocial factors and cardiovascular diseases. Annu Rev Public Health. 2005;26:469-500.

377. Colquhoun DM, Bunker SJ, Clarke DM, Hare DL, Hickie IB, Tatoulis J, et al. Psychosocial risk factors for coronary heart disease. The Medical Journal of Australia. 2013;199(3):1-6.

378. Pedersen SS, von Känel R, Tully PJ, Denollet J. Psychosocial perspectives in cardiovascular disease. European journal of preventive cardiology. 2017;24(3_suppl):108-15.

379. Biswas T, Pervin S, Tanim MIA, Niessen L, Islam A. Bangladesh policy on prevention and control of non-communicable diseases: a policy analysis. BMC public health. 2017;17(1):582.

380. Bangladesh Health Watch. Non-Communicable Diseases in Bangladesh Current Scenario and Future Directions. Dhaka, Bangladesh: Bangladesh Health Watch; 2017.

381. The World Bank. In Bangladesh, Empowering and Employing Women in the Garments Sector: The World Ban; 2017 [Available from: http://www.worldbank.org/en/news/feature/2017/02/07/in-bangladesh-empowering-and-employing-women-in-the-garments-sector.

Annexure

Annexure 1.1

Table 1. 1: Characteristics of studies

Study, Publication year	Country	Total Sample	Migrant	Rural	Urban	Gender	% of male	Mean age or Age group	Urban exposure	Study design	Sampling	Reported CVD risk factors
Kusuma Y et al, 2009	India	453	People who recently migrated for the first time to the Delhi city from northern Indian states and Settled migrant who have migrated and residing in Delhi for ≥10 years	-	-	M, F	49	34	<2 years and ≥10 years	Cross-sectional	Random sampling; Traced cohort	Height, weight, BMI, mid upper arm circumference, waist circumference, hip circumference, waist/hip ratio, tricep, subscapular, hypertension
Gupta R et al, 2012	India	4274	Women whose origin is rural and migrated to urban India- Jaipur, Kolkata, Pondicherry and Kochi	Women whose previous and current place of residence is rural India- Haryana, Rajasthan, maharashtra, Pondicherry and tamil Nadu	Women whose previous and current place of residence is Urban India- Jaipur, Kolkata, Pondicherry and Kochi	F	0	35-70 years	9.2±16.6	Cross-sectional	Systematic stratified sampling	Physical activity, diet, weight, BMI, waist circumference, W:H ratio, SBP, TC, FBG,
Duboz P et al, 2012	Senegal	197	People who were born in rural (small town of less than 10,000 inhabitants) and living in Dakar for more than 1 year	-	People who born and living in Dakar	M, F	51	20-29 30-39 40-49 >50 years	>1 year	Cross-sectional	Quota sampling	BMI, waist circumference, SBP, DBP

Table 1.1 (continue)

Study, Publication year	Country	Total Sample	Migrant	Rural	Urban	Gender	% of male	Mean age or Age group	Urban exposure	Study design	Sampling	Reported CVD risk factors
Varadharajan KS et al, 2013	India	87335	People who moved from rural to urban India from National Family Health survey	Rural people whose current and previous place of residence is same from National Family Health survey	Urban people whose current and previous place of residence is same National Family Health survey	M, F	60	29.7	>5 years	Cross-sectional	National survey	Diet, height, overweight/ obesity,
Zhao J et al, 2014	Thailand	51936	Students of open university recently migrated to urban area during 2005 to 2009 and medium term migrants who were in rural areas when they were aged 10-12 years, but had migrated to an urban area by 2005	Students of open university who were living in rural area for long term	Students of open university who were living in urban areas for long term	M, F	45	29-49 years	>0 years	Prospective cohort	National cohort	Smoking, alcohol, physical activity, BMI, Hypertension, Hyperlipidemia,
Doulougou et al, 2014	Bukrina Faso	2041	Participants those who came from outside of Ouagadougou and residing for less than 10 years and more than 10 years	-	Participants those who native of Ouagadougou	M, F	44	42.5	<10 years >10 years	Cross-sectional	Health and Demographic Surveillance System (HDSS) sample	Physical activity, smoking, alcohol intake, Weight, BMI,SBP, DBP

Table 1.1 (continue)

Study, Publication year	Country	Total Sample	Migrant	Rural	Urban	Gender	% of male	Mean age or Age group	Urban exposure	Study design	Sampling	Reported CVD risk factors
Oyebode O et al, 2015	China, Ghana, India, Mexico, Russia, South Africa	39436	Study participants of WHO Study on global AGEing and adult health (SAGE) who were a current resident of an urban area and if they reported that either their previous place of residence was rural, or that they had lived most of their adulthood or childhood in a rural area	participants who were a current resident of a rural area and had lived there all their life, or reported living only in other rural areas previously	participants who were a current resident of an urban area and had lived there all their life, or reported living only in other urban areas previously	M, F	44	52.9	Not reported	Cross-sectional	Household sampling	smoking, alcohol intake, physical activity, diet, overweight, obesity, waist circumference, hypertension, diabetes
Norboo et al, 2016	India	2800	Migrants (Tibetan and Ladakhi nomads) settled in Leh town from Changthang area of Ladakh, northernmost part of India	People from rural areas of six subdivision of Ladakh	Tibetans and Ladhaki people born in Leh Town and some migrants from rural areas except Changthang who were living in Leh Town	M, F	44	53.8	Not reported	Cross-sectional	Two stage stratified sampling	Weight, BMI SBP, DBP

Table 1. 2: Summary of study findings

Study	Country	Comparison groups	Summary of findings
Kusuma Y et al, 2009	India	Neo (recent) migrants and settled migrants	• Settled migrants of both genders possessed higher mean of BMI, waist circumference, hip circumference, tricep, subscapular and SBP than neo (recent) migrants. • However, mean mid upper arm circumference was higher among neo migrant than settle migrant and mean DBP showed slightly higher in neo migrant men than settled-migrant men. • Prevalence of hypertension ranged from 15% (neo migrant women) to 25% (settled migrant men but younger neo migrants (≤34 years) had higher prevalence of hypertension than their settled migrant counterparts.
Gupta R et al, 2012	India	Rural, rural-to-urban migrant and urban women	• The prevalence of high fat diet, overweight and obesity and mean BMI was the lowest in rural women, intermediate in rural-to-urban migrant women and highest in urban women • But in case of waist circumference, waist:hip ratio, hypertension, total cholesterol, diabetes, this gradient was not observed, and rural-to-urban migrant showed highest risk than other two groups. • Tobacco consumption was highest in rural women • There was a significant correlation of duration of migration and waist circumference, waist:hip ratio and SBP among rural-to-urban migrants
Duboz P et al, 2012	Senegal	Rural-to-urban migrants and urban residents	• Mean SBP and DBP was higher in migrants than urban group, though no difference was observed among women. • Length of residence at urban was positively associated with SBP and DBP and the risk of hypertension increases with successive decade of urban exposure after adjusting SES.
Varadharajan KS et al, 2013	India	Rural, rural-to-urban migrant and urban	• Reported daily /weekly consumption of dairy and fruit intake was higher in rural-to-urban migrants than rural but lower than urban non-migrant. • Vegetable intake was higher in migrant and urban group than rural. While migrant women reported lowest frequency of egg, fish and meat consumption than non-migrants, similar consumption was observed among migrant men and non-migrant urban men. • Women were likely to be overweight/obese than men in all groups. • Migrant women but not men showed higher odds of overweight/obese than non-migrant rural group (AOR 1.5 95% CI 1.36-1.65)

Table 1.2 (continue)

Study	Country	Comparison groups	Summary of findings
Zhao J et al, 2014	Thailand	Rural, recent and medium term rural-to-urban migrant and urban	• Although smoking prevalence was lower among women than men, the prevalence increased with duration of urban stay. In case of male, the prevalence was quite similar in all groups. Similar pattern was observed for alcohol intake • Weekly physical activity was highest in rural group, lowest in urban group and migrant groups were in between them. BMI was markedly higher among medium term migrant men than rural men. • Recent rural-to-urban migrants had greater risk of hypertension than rural (OR 1.22 (1.05-1.41)), but it was not observed for medium term migrant • Relative to rural group, migrants and urban group showed higher risk of hyperlipidemia (OR from 1.29 to 1.48)
Doulougou et al, 2014	Bukrina Faso	Recent and established rural-to-urban migrants and urban residents	• Recent rural-to-urban migrants (<10 years) (OR = 1.8; 95% CI, 1.2-2.8) were more likely to be hypertensive than urban resident while the odds of being hypertensive did not differ between the more established migrants (more than 10 years) and the native population.
Oyebode O et al, 2015	China, Ghana, India, Mexico, Russia, South Africa	Rural, rural-to-urban migrant and urban	• Current smoking was lower among migrant and urban groups than rural in pooled analysis and in China, Ghana and India. This contrast in Mexico where current smoking was significantly higher in migrant and urban than rural. In Russia, migrant had lower rate but urban had higher rate of smoking than rural. • Alcohol intake was significantly lower in migrant and urban group than rural in pooled analysis. This pattern was observed in China and Ghana but not in other countries. • Fruit and vegetable consumption >5 5 portions/day was lower in migrants than rural group in pooled analysis. In country level data, the consumption was lower in migrants than rural in China, Ghana, India, Mexico. In contrast, higher intake of fruit and vegetable was observed in South Africa among migrant than rural. • Occupational physical activity (PA) was significantly lower in migrant and urban group in pooled analysis. Although this pattern was observed for China, Ghana, Mexico and Russia, migrant group of India and South Africa were most likely to be physically active at work (1.10 (1.01-1.17); 2.01 (1.53-2.28)). In contrast, leisure time PA and active travel were significantly higher in migrant and urban group in pooled analysis. In country level data, this pattern was mixed.

Table 1.2 (continue)

Study	Country	Comparison groups	Summary of findings
			• Overweight, obesity and waist circumference were significantly higher in migrant and urban than rural. This pattern was observed for all countries except Russia where migrant all indicators showed lower level in migrants than rural. • In pooled analysis no association was observed for hypertension. However, in country level analysis Mexico had significantly higher level of prevalence in migrant group • In contrast, diagnosed diabetes showed consistent pattern across all countries and in pooled analysis which was higher in migrant and urban than rural.
Norboo et al, 2016	India	Rural, rural-to-urban migrant and urban	• The prevalence of hypertension was highest in migrant (48%), followed by urban (41%) than rural (34%). After adjusting confounders, migrants were at 1.7 times and urban were at 1.92 times higher risk to develop hypertension than rural.

Annexure 1.2

Table 1. 3: Summary of assessment tools of physical activity

Sl No	Author, year	Country	Instrument name	Ref Period	Domain	intensity	Frequency	Measurement unit	Summary measure	Validity	Reliability	Ref
1	Unwin N, 2010	Tanzania	Questionnaire Name not mentioned	Usual day	Five categories asked: spending most of the day sitting (at a desk, at home or outside); spending most of the day on one's feet, carrying, cleaning etc; spending most of one's day digging, hoeing, carrying heavy objects etc	light, moderate & vigorous				Not stated		
2	Ebrahim S, 2010	India	Questionnaire Name not mentioned	Past month	Leisure time, household chores, work, sleep, sedentary activities and other common daily activities	Sedentary, light & moderate	reported frequency to fixed categories- daily, once a week, 2-4 times a week, 5-6 times a week, once a month, 2-3 times a month	Metabolic Equivalent Tasks (METs), Integrated Energy Index (IEI) for manual occupational activity which take into account 'rest' & 'pause' period	METs hr/day	49 rural & 45 urban participant Compared with uni-axial accelerometer (r=0.28; p<0.01) and a 24-h activity diary (r=0.30; p<0.01)		Published

Table 1.3 (continue)

Sl No	Author, year	Country	Instrument name	Ref Period	Domain	intensity	Frequency	Measurement unit	Summary measure	Validity	Reliability	Ref
3	Creber RMM, 2010	Peru	International Physical Activity Questionnaire (IPAQ)	Last 7 days	Job related, transportation, Housework, house maintenance & caring for family, recreation, sport & leisure time, time spent sitting	Light, moderate & vigorous	-	METs	MET min/week	Yes	-	-
4	Torun B, 2002	Guatemala	Questionnaire Name not mentioned	typical 24-hr period on weekdays and weekends	work, leisure and other activities	-	-	METs	-	no indication	test-retest evaluation (r=0.90 & r=0.82 for men & women)	Published
5	Yamauchi T, 2001	Papua New Guinea	Cardio-frequency meter for heart monitor	24-hr period	work, leisure and other activities	Sleep, sedentary, moderate active, highly active	-	-	BMR, TEE (MJ/d), PAL	-	-	-
6	He J	China	Questionnaire Name not mentioned	-	-	-	-	-	-	-	-	-

Table 1.3 (continue)

Sl No	Author, year	Country	Instrument name	Ref Period	Domain	intensity	Frequency	Measurement unit	Summary measure	Validity	Reliability	Ref
7	Gupta R et al, 2012	India	Single page physical activity questionnaire	Last 4 week	Work, sport, hobby, household chores, sedentary, sleep			METs	PAL	Yes		Published
8	Zhao J et al, 2014	Thailand	Four questions	A typical week (7 day)	Walk, moderate & vigorous PA	Moderate, vigorous	'<7 sessions' or '≥7 sessions			No		
9	Oyebode O et al, 2015	China, Ghana, India, Mexico, Russia, South Africa			Occupation, leisure, travel	Moderate, vigorous	75 minutes of vigorous or 150 minutes of moderate exercise/week					

Table 1. 4: Summary of assessment tools of diet

Sl No	Author, year	Country	Instrument name	Item	Frequency	Validity	Reliability	Ref
1	Unwin N, 2010	Tanzania	Food Frequency Questionnaire (FFQ)	20	never, 1-2, 3-5, 6-7 days/week heavy objects etc	Not stated		-
2	Ebrahim S, 2010	India	Interviewer-administered semi quantitative FFQ	184	daily, weekly, monthly, yearly/never	Done. Three 24-hr recall	checked (ƙ= 0.26-0.7)	Yes
3	Torun B, 2002	Guatemala	FFQ	52	3 months	Done. Three non-consecutive 24-hour dietary recalls	checked (ƙ= 0.26-0.7)	Yes
4	Yamauchi T, 2001	Papua New Guinea	Weighing method Laboratory analysis for local foods	-	Whole day	-	-	-
5	Varadharajan KS et al, 2013	India	-	-	Daily/weekly intake of food groups			
6	Gupta R et al, 2012	India	2 Day 24 hr recall	-		-	-	
7	Oyebode O et al, 2015	China, Ghana, India, Mexico, Russia, South Africa	fruit and vegetable consumption		portions/day	-	-	-

Annexure 2.1

As men and women questionnaires used in UHS 2006 were quite similar, here we have presented only Female Questionnaire and included the parts which were used for analysis.

Full questionnaire is available here: http://catalog.ihsn.org/index.php/catalog/141

Urban Health Survey
2006

Female Questionnaire

NATIONAL INSTITUTE OF POPULATION RESEARCH AND TRAINING (NIPORT)
Ministry of Health and Family Welfare,
Azimpur, Dhaka

ASSOCIATES FOR COMMUNITY AND POPULATION RESEARCH (ACPR)
3/10, Block A, Lalmatia, Dhaka-1207

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E-MAIL: acpr@bangla.net

MEASURE *Evaluation*

USA

FEMALE QUESTIONNAIRE

IDENTIFICATION

DIVISION .... (BARISAL=1; CHITTAGONG=2; DHAKA=3; KHULNA=4; RAJSHAHI=5; SYLHET=6) ☐

DISTRICT.. ☐☐

THANA .... ☐☐

WARD/UNION .... ☐☐☐

MOHALLA/MOUZA..

DOMAIN ☐
1 = DHAKA METROPOLITAN AREA: LARGE SLUM
2 = DHAKA METROPOLITAN AREA: MEDIUM/SMALL SLUM
3 = DHAKA METROPOLITAN AREA: NON-SLUM
4 = CHITTAGONG CITY CORPORATION: SLUM
5 = CHITTAGONG CITY CORPORATION:NON SLUM
6 = OTHER CITY CORPORATION: SLUM
7 = OTHER CITY CORPORATION: NON-SLUM
8 = DISTRICT MUNICIPALITY

PSU NUMBER .... ☐☐☐

HOUSEHOLD NUMBER.. ☐☐☐

TYPE OF HOUSEHOLD: 1 = NON-MESS 2 = MESS ☐

NAME AND LINE NUMBER OF RESPONDENT ______________________ ☐☐

INTERVIEWER VISITS

	1	2	3	FINAL VISIT
DATE	______	______	______	DAY ☐☐ MONTH* ☐☐ YEAR ☐☐☐☐
INTERVIEWER'S NAME	______	______	______	CODE ☐☐☐
RESULT*	______	______	______	RESULT** ☐
NEXT VISIT: DATE	______	______		TOTAL NO. OF VISITS ☐
TIME	______	______		

**RESULT CODES :

1 COMPLETED
2 NOT AT HOME
3 POSTPONED
4 REFUSED
5 PARTLY COMPLETED
6 RESPONDENT INCAPACITATED
7 OTHER ______________ (SPECIFY)

*MONTH CODES

01 JANUARY	04 APRIL	07 JULY	10 OCTOBER
02 FEBRUARY	05 MAY	08 AUGUST	11 NOVEMBER
03 MARCH	06 JUNE	09 SEPTEMBER	12 DECEMBER

SUPERVISOR	FIELD EDITOR	OFFICE EDITOR	KEYED BY
NAME ______ ☐☐ DATE ______	NAME ______ ☐☐ DATE ______	☐☐	☐☐

Section 1: Basic Individual Characteristics

Starting time: Hour ☐☐ Minutes ☐☐

NO.	QUESTIONS AND FILTERS	CODING CATEGORIES	SKIP
	BASIC CHARACTERISTICS		
101.	In what month and year were you born?	Month ☐☐ Don't know month 98 Year ☐☐ Don't know year 9998	
101a.	How old are you at your last birthday?	Age in completed years ☐☐	
102.	Are you married, separated, deserted, widowed or divorced?	Currently married 1 Separated 2 Deserted 3 Widowed 4 Divorced 5 Never married 6	
103.	**INTERVIEWER: CHECK Q.101a AND 102 AND CIRCLE IN APPROPRIATE CODE.**	**Less than 18 year and never married 1** **Above 59 years 2** **Less than 18 year and ever married 3** **Age 18-59 and ever/never married 4**	**Terminate interview** (1, 2)
104.	Have you ever attended school?	Yes 1 No 2	2 → **105**
104a.	What level of schooling have you last attended?	Level ☐	
104b.	What is the highest grade of schooling completed?	Grade ☐☐	
104c.	**INTERVIEWER: CHECK Q. 104b AND CIRCLE IN APPROPRIATE CODE.**	**Grade is 6 or more 1** **Grade is less than 6 2**	1 → **106**
105.	Can you read or write a letter in any language easily, with difficulty or not at all?	Easily 1 With difficulty 2 Not at all 3	3 → **107**
	BASIC CHARACTERISTICS: METHODS OF TRANSPORTATION AND MEDIA EXPOSURE		
106.	Do you usually read a newspaper or magazine?	Yes 1 No 2	2 → **107**
106a.	How often do you read a newspaper or magazine: everyday; at least once a week; less than once a week?	Everyday 1 At least once a week 2 Less than once a week 3	
107.	Do you listen to the radio?	Yes 1 No 2	2 → **108**
107a.	How often do you usually listen to the radio: everyday; at least once a week; less than once a week?	Everyday 1 At least once a week 2 Less than once a week 3	
108.	Do you watch television?	Yes 1 No 2	2 → **109**

Section 1: Basic Individual Characteristics

Starting time: Hour [ ][ ] Minutes [ ][ ]

NO.	QUESTIONS AND FILTERS	CODING CATEGORIES	SKIP
	BASIC CHARACTERISTICS		
101.	In what month and year were you born?	Month......[ ][ ] Don't know month......98 Year......[ ][ ] Don't know year......9998	
101a.	How old are you at your last birthday?	Age in completed years......[ ][ ]	
102.	Are you married, separated, deserted, widowed or divorced?	Currently married......1 Separated......2 Deserted......3 Widowed......4 Divorced......5 Never married......6	
103.	**INTERVIEWER: CHECK Q.101a AND 102 AND CIRCLE IN APPROPRIATE CODE.**	**Less than 18 year and never married......1** **Above 59 years......2** **Less than 18 year and ever married......3** **Age 18-59 and ever/never married......4**	**1, 2 → Terminate interview**
104.	Have you ever attended school?	Yes......1 No......2	2 → **105**
104a.	What level of schooling have you last attended?	Level......[ ]	
104b.	What is the highest grade of schooling completed?	Grade......[ ][ ]	
104c.	**INTERVIEWER: CHECK Q. 104b AND CIRCLE IN APPROPRIATE CODE.**	**Grade is 6 or more......1** **Grade is less than 6......2**	1 → **106**
105.	Can you read or write a letter in any language easily, with difficulty or not at all?	Easily......1 With difficulty......2 Not at all......3	3 → **107**
	BASIC CHARACTERISTICS: METHODS OF TRANSPORTATION AND MEDIA EXPOSURE		
106.	Do you usually read a newspaper or magazine?	Yes......1 No......2	2 → **107**
106a.	How often do you read a newspaper or magazine: everyday; at least once a week; less than once a week?	Everyday......1 At least once a week......2 Less than once a week......3	
107.	Do you listen to the radio?	Yes......1 No......2	2 → **108**
107a.	How often do you usually listen to the radio: everyday; at least once a week; less than once a week?	Everyday......1 At least once a week......2 Less than once a week......3	
108.	Do you watch television?	Yes......1 No......2	2 → **109**

NO.	QUESTIONS AND FILTERS		CODING CATEGORIES	SKIP
118.	Approximately what is the total number of months you work per year at this job? Months .... ☐☐ Worked less than 1 year 95		118a. Approximately what is the total number of months you work per year at this job? Months .... ☐☐ Worked less than 1 year 95	
119.	For whom do you work? Working for a family business for pay .... 1 Working for private company .... 2 Working for Government .... 3 Self-employed .... 4 Working for a family business for no pay .... 5 Day labour 6	 →121 →122	119a. For whom do you work? Working for a family business for pay .... 1 Working for private company .... 2 Working for Government .... 3 Self-employed .... 4 Working for a family business for no pay .... 5 Day labour 6	 →121a →125
120.	Approximately what was your net salary/wage during the last month? Taka .... ☐☐☐☐☐	→122	120a. Approximately what was your net salary/wage during the last month? Taka .... ☐☐☐☐☐	→125
121.	Approximately how much net profit did you gain last month, after taking out your business expenses? Taka .... ☐☐☐☐☐		121a. Approximately how much net profit did you gain last month, after taking out your business expenses? Taka .... ☐☐☐☐☐	→125
122.	Do you currently have any other job? Yes .... 1 No 2		→ **Back to 116a and ask about secondary work** → **125**	
123.	Have you ever worked before?		Yes .... 1 No 2	
124.	Are you actually looking for any work?		Yes .... 1 No 2	
	BASIC CHARACTERISTICS: MIGRATION HISTORY			
125.	Where were you born?		City corporation________1 (Specify) ☐☐ District town________2 (Specify) Other town________3 ☐☐ (Specify Upazila) Village________4 (Specify Upazila) Abroad________99995 (Specify)	
126.	For most of the time until you were 12 years old, did you live in a city, in a town, or in the countryside?		City corporation (Dhaka/Khulna/Rajshahi/ Barisal/Chittagong/Sylhet) .... 1 District town .... 2 Other town .... 3 Village .... 4 Abroad 5	

NO.	QUESTIONS AND FILTERS	CODING CATEGORIES	SKIP
127.	How long have you been living continuously in ________ (NAME OF CURRENT PLACE OF RESIDENCE)?	Number of years .... [ ][ ] Less than 1 year .... 95 Always 99	→ 134 (Always)
128.	Where did you live before this?	City corporation ________ 1 (Specify) District town ________ 2 (Specify) [ ][ ] Other town ________ 3 (Specify Upazila) [ ][ ] Village ________ 4 (Specify Upazila) Abroad ________ 99995 (Specify)	
129.	What was the main reason for moving to the current place?	Looking for work .... 01 For more earning .... 02 Service/work/for transfer .... 03 For own education .... 04 For children's education .... 05 For familial .... 06 For marriage .... 07 Buy new land/house .... 08 Look after properties .... 09 For river erosion .... 10 For eviction .... 11 For security .... 12 Other ________ .... 96 (Specify)	

129a. Is there any other reason for moving to the current place?

(Interviewer: Circle code 1 in Q.129a for each reason mentioned spontaneously. Read out each reason not mentioned spontaneously, then circle code 2 if answer is yes and code 3 for no.)

(First you circle code 1 for which reason code in Q.129 already was circled then ask Q.129a .)

	Unprompted Yes	Prompted Yes	No
Looking for work	1	2	3
For more earning	1	2	3
Service/work/for transfer	1	2	3
For own education	1	2	3
For children's education	1	2	3
For familial	1	2	3
For marriage	1	2	3
Buy new land/house	1	2	3
Look after properties	1	2	3
For River erosion	1	2	3
For eviction	1	2	3
For security	1	2	3
Other ________ (Specify)	1	2	3

BASIC CHARACTERISTICS: CIRCULAR MIGRATION

NO.	QUESTIONS AND FILTERS	CODING CATEGORIES	SKIP
130.	Did you live in this city/town all of the last year?	Yes .... 1 No 2	→ 134 (Yes)
130a.	How much of the last year did you spend here?	Weeks .... [ ][ ]	

NO.	QUESTIONS AND FILTERS	CODING CATEGORIES	SKIP
130b.	Which months during the last year did you spend here? (Please convert in English month if respondent mentioned Bangla month then circle in appropriate code.)	January ..... A February ..... B March ..... C April ..... D May ..... E June ..... F July ..... G August ..... H September ..... I October ..... J November ..... K December ..... L No specific time ..... Z	
130c.	Why did you spend part of the year here?	Looking for work ..... A For more work ..... B Service/work/for transfer ..... C For own education ..... D For children's education ..... E Lived with family ..... F Buy new land/house ..... G Look after properties ..... H For river erosion ..... I For eviction ..... J For security ..... K Visiting relatives/friends ..... L For illness of family members/relatives ..... M For joining the family program ..... N For joining the religious program ..... O Other ________ ..... X (Specify)	
131.	Other than here, where did you spend the most time last year?	Division ________ [ ][ ] Thana ________ [ ][ ][ ]	
131a.	Is that place: a city corporation? a district town? another town? a village?	City corporation________1 (Specify) District town________2 [ ][ ] (Specify) Other town________3 [ ][ ] (Specify Upazila) Village________4 (Specify Upazila) Abroad________99995 (Specify)	
131b.	How much of the last year did you spend there?	Weeks ..... [ ][ ]	

NO.	QUESTIONS AND FILTERS	CODING CATEGORIES	SKIP
131c.	Which months during the last year did you spend there? (Please convert in English month if respondent mentioned Bangla month then circle in appropriate code.)	January .... A February .... B March .... C April .... D May .... E June .... F July .... G August .... H September .... I October .... J November .... K December .... L No specific time .... Z	
131d.	Why did you spend part of the year there?	Looking for work .... A For more work .... B Service/work/for transfer .... C For own education .... D For children's education .... E Lived with family .... F Buy new land/house .... G Look after properties .... H For river erosion .... I For eviction .... J For security .... K Visiting relatives/friends .... L For illness of family members/relatives .... M For joining the family program .... N For joining the religious program .... O Other ______ .... X (Specify)	
132.	**INTERVIEWER: SEE 131a FOR NAME OF CITY/TOWN/VILLAGE AND ASK……..** Other than here ______ (Current city/town) and ______ (Answer of Q131a) did you live anywhere else last year?	Yes .... 1 No 2	 → **134**
133.	In what thana and division?	Division ______ ☐☐ Thana ______ ☐☐☐	
133a.	Is that place: a city corporation, a district town, another town, or a village?	City corporation ______ 1 (Specify) District town ______ 2 ☐☐ (Specify) Other town ______ 3 ☐☐ (Specify Upazila) Village ______ 4 (Specify Upazila) Abroad ______ 99995 (Specify)	

NO.	QUESTIONS AND FILTERS	CODING CATEGORIES	SKIP
133b.	How much of the last year did you spend there?	Weeks .... [ ][ ]	
133c.	Which months during the last year did you spend there? (Please convert in English month if respondent mentioned Bangla month then circle in appropriate code.)	January .... A February .... B March .... C April .... D May .... E June .... F July .... G August .... H September .... I October .... J November .... K December .... L No specific time .... Z	
133d.	Why did you spend part of the last year there?	Looking for work .... A For more work .... B Service/work/for transfer .... C For own education .... D For children's education .... E Lived with family .... F Buy new land/house .... G Look after properties .... H For river erosion .... I For eviction .... J For security .... K Visiting relatives/friends .... L For illness of family members/relatives .... M For joining the family program .... N For joining the religious program .... O Other ________ .... X (Specify)	
	BASIC CHARACTERISTICS: HEALTH CARE FINANCING AND DECISION MAKING		
134.	**INTERVIEWER: CHECK Q.102 AND CIRCLE IN APPROPRATE CODE.**	**Currently married** .... 1 **Separated** .... 2 **Deserted** .... 3 **Widowed** .... 4 **Divorced** .... 5 **Never married** 6	→ **401**
135.	**INTERVIEWER: CHECK Q.101a AND CIRCLE IN APPROPRIATE CODE.**	**Age less than 50** .... 1 **Age 50 or above** 2	→ **301**
136.	Who exactly in your household makes final decisions about […]? A. Your health care B. Your children's health care C. Making large household purchases D. Making household purchases for daily needs E. Visits to family, friends or relatives F. What food should be cooked each day	1=Respondent; 2=Spouse; 3=Respondent and husband jointly; 4=Someone else; 5=Respondent and someone else jointly A 1 2 3 4 5 B 1 2 3 4 5 C 1 2 3 4 5 D 1 2 3 4 5 E 1 2 3 4 5 F 1 2 3 4 5	

Section 4: General Health

Now I would like to ask you a few questions related to your health. We would like to know specifically whether in recent time you faced any difficulty in doing normal work for any health problems, experienced serious illness or injury.

NO.	QUESTIONS AND FILTERS	CODING CATEGORIES	SKIP
	HEALTH AND HEALTH CARE UTILIZATION		
401.	In general, how is your health? very healthy; somewhat healthy; somewhat unhealthy; unhealthy.	Healthy .... 1 Somewhat healthy .... 2 Somewhat unhealthy .... 3 Unhealthy 4	
402.	During the last 4 weeks, for any health problem(s), did you have difficulty in doing your normal work, or in doing regular activities?	Yes .... 1 No 2	→ 403
402a.	For how many days in the last 4 weeks were you unable to do your normal work or regular activities due to this (these) health problem(s)?	Days .... [ ][ ] Still 95	

402b.	If you had to ----------could you do it? **(READ OUT)**	Easily	With difficulty	Not at all
	A. Can you feed yourself?	1	2	3
	B. Carry a heavy load, such as 10 KG?	1	2	3
	C. Walk 1 kilometers?	1	2	3
	D. Bow, squat, kneel?	1	2	3
	E. Dress without help?	1	2	3
	F. Go to the bathroom without help?	1	2	3
	G. Stand up from a sitting position in a chair without help?	1	2	3
	H. Stand up from sitting on the floor without help?	1	2	3

NO.	QUESTIONS AND FILTERS	CODING CATEGORIES	SKIP
403.	In the last year, did you experience any serious illness?	Yes .... 1 No 2	→ **404**
403a.	How long did it last?	Days .... [ ][ ] Ongoing 99	
404.	In the last year, did you suffer any serious injury?	Yes .... 1 No 2	→ **501**
404a.	What happened?	Road accident .... A Domestic accident .... B Occupational accident .... C Domestic violence .... D Violence outside home .... E Other ____________ .... X (Specify)	
404b.	During the last 4 weeks, for any serious injury, did you have difficulty in doing your normal work, or in doing regular activities?	Yes .... 1 No 2	→ **501**
404c.	For how many days in the last 4 weeks were you unable to do your normal work or regular activities due to this (these) serious injury?	Days .... [ ][ ] Still 95	

Section 6: Physical Measurements

NO.	QUESTIONS AND FILTERS	CODING CATEGORIES	SKIP
601.	**INTERVIEWER: MEASURE THE HEIGHT AND WEIGHT AND RECORD IN APPROPRIATE BOX.**	Height .... ☐☐☐.☐ (In centimeter) Weight .... ☐☐☐.☐ (In KG)	
602.	**INTERVIEWER: CHECK Q.101a AND CIRCLE IN APPROPRIATE CODE.**	**Age less than 35 years........ 1** **Age 35-59 years........ 2**	**→ 701**
603.	Do you have high blood pressure?	Yes........ 1 No........ 2 Don't know........ 8	→ 603c
603a.	Did you seek any treatment?	Yes........ 1 No........ 2	
603b.	Do you take any medication?	Yes........ 1 No........ 2	
603c.	**INTERVIEWER: CHECK THE BLOOD PRESSURE AND RECORD IN APPROPRIATE BOX.**	Systolic .... ☐☐☐ Diastolic .... ☐☐☐	
604.	Do you have diabetes?	Yes........ 1 No........ 2 Don't know........ 8	→604c
604a.	Did you seek any treatment?	Yes........ 1 No........ 2	
604b.	Do you take any medication?	Yes........ 1 No........ 2	
604c.	Have you taken your breakfast?	Yes........ 1 No........ 2	→ 604e
604d.	**INTERVIEWER: IF THE RESPONDENT TOOK HER BREAKFAST, THEN REQUEST THE RESPONDENT TO REMAIN FASTING UNTIL YOU ARRIVE THERE IN THE NEXT MORNING FOR TAKING BLOOD SAMPLE.**		
604e.	**INTERVIEWER: ENSURE THAT THE RESPONDENT IS FASTING AND THEN COLLECT BLOOD SAMPLE FOR BLOOD GLUCOSE AND RECORD IN APPROPRIATE BOX.**	MG/DL........ ☐☐☐	

Section 7. Mental Health

Now I would like to know from you about certain mental conditions that a person may often experience. I would like to know whether you experience any such conditions during the last 1 month. Answer yes or no.

NO.	QUESTIONS AND FILTERS	CODING CATEGORIES	SKIP
701.	During the last 1month did you often have been nervous, tense or worried?	Yes........................1 No........................2	
702.	During the last 1month were you frightened easily?	Yes........................1 No........................2	
703.	During the last 1month did you generally feel unhappy?	Yes........................1 No........................2	
704.	During the last 1month did you often find it difficult to make decisions?	Yes........................1 No........................2	
705.	During the last 1month have you had headache quite often?	Yes........................1 No........................2	
706.	Have you had any problem to think clearly during the last four weeks?	Yes........................1 No........................2	
707.	During the last 1month did you find it difficult to enjoy daily activities?	Yes........................1 No........................2	
708.	During the last 1month did you often lose interest in things?	Yes........................1 No........................2	
709.	During the last 1month have you constantly felt tired?	Yes........................1 No........................2	
710.	During the last 1month have you had loss of appetite?	Yes........................1 No........................2	
711.	During the last 1month have you had problem with sleep?	Yes........................1 No........................2	
712.	During the last 1month do you often have uncomfortable feelings in your stomach?	Yes........................1 No........................2	
713.	During the last 1month have you often experienced shaking of hands?	Yes........................1 No........................2	
714.	During the last 1month have you often felt tired?	Yes........................1 No........................2	
715.	During the last 1month did you cry more than normal?	Yes........................1 No........................2	
716.	During the last 1 month has your daily activities suffered in any way?	Yes........................1 No........................2	
717.	During the last 1month have you thought of ending your life?	Yes........................1 No........................2	
718.	During the last 1month did you feel as if you are unable to play a useful part in life?	Yes........................1 No........................2	
719.	During the last 1month did you suffer from poor digestion?	Yes........................1 No........................2	
720.	During the last 1month did you feel worthless?	Yes........................1 No........................2	

Section 9: Smoking, Alcohol and Drug Use AND Crime

Now I would like to ask you a very personal question. Some people take such things as cigarette, bidi, hukka, ganja, charas, phensidle, pethedine, heroin, morphin, etc. I would like to know if you have any such habits. The information you provide shall be kept confidential and be used only for research purposes like the other information.

NO.	QUESTIONS AND FILTERS	CODING CATEGORIES			SKIP
901.	In the last 1 months, have you taken ________? **(Read out)**	**Smoking**	**Yes**	**No**	
		Cigarette	1	2	→ 906
		Bidi	1	2	
902.	**INTERVIEWER: CHECK Q.901 AND CIRCLE IN APPROPRIATE CODE.**	**Code 1 for cigarette and bidi is circled....1** **Code 1 for cigarette is circled....2** **Code 1 for bidi is circled....3**			**→905**
903.	Do you smoke cigarette currently?	Yes....1 No....2			**→904**
903a.	How many cigarettes do you smoke in a typical day?	No of cigarette....[ ][ ]			
904.	**INTERVIEWER: CHECK Q.902 AND CIRCLE IN APPROPRIATE CODE.**	**Code 1 is circled....1** **Code 1 is not circled....2**			**→906**
905.	Do you smoke bidi currently?	Yes....1 No....2			**→906**
905a.	How many bidi do you smoke in a typical day?	No of bidi....[ ][ ]			
906..	Have you ever used drugs/alcohol?	Yes....1 No....2			**→907**
906a.	In the last 1 month, have you taken ________? **(Read out)**	**Drug/Alcohol**	**Yes**	**No**	
		Ganja	1	2	
		Charas	1	2	
		Phensidle	1	2	
		Heroin	1	2	
		Tari (Locally made wine)	1	2	
906b.	**INTERVIEWER: CHECK Q.906a AND CIRCLE IN APPROPRIATE CODE.**	At least one code 1 is circled....1 No code 1 is circled....2			**→907**
906c.	In the last 3 month, have you taken ________? (Drug/Alcohol)	Days....[ ][ ]			
906d.	At what age did you first take the ________? (Drug/Alcohol)	Age....[ ][ ]			
907.	Have you ever injected any drugs?	Yes....1 No....2			**→ 908**
907a.	In the last 1 month, have you taken ________? (Drug) **(Read out)**	**Drug**	**Yes**	**No**	
		Pethedine	1	2	
		Morphin	1	2	

NO.	QUESTIONS AND FILTERS	CODING CATEGORIES	SKIP
907b.	**INTERVIEWER: CHECK Q.907a AND CIRCLE IN APPROPRIATE CODE.**	**At least one code 1 is circled ....1** **No code 1 is circled 2**	**→908**
907c.	How many days have you taken ________ in the last 1 month? (Drug)	Days.. ☐☐	
907d.	At what age did you first take the ________? (Drug)	Age .... ☐☐	
908.	Have you experienced extortion or attempt of extortion in the last 6 months?	Yes.. 1 No.. 2	**→ 909**
908a.	How many times?	Times.. ☐☐	
909.	Have you faced hijacking or attempt of hijacking in the last 6 months?	Yes.. 1 No.. 2	**→ 909b**
909a.	How many times?	Times.. ☐☐	
909b	**INTERVIEWER: CHECK Q.908 AND Q.909 AND CIRCLED IN APPROPRIATE CODE.**	**Code 1 circled in both Q. 908 and Q.909 .... 1** **Code 1 circled in Q. 908 or Q.909** .... 2 **Code 2 circled in both Q. 908 and Q.909** 3	**→ 910**
909c.	Did any of these incidents lead to any kind of injury?	Yes.. 1 No.. 2	**→ 909e**
909d.	Was the injury serious ?	Yes.. 1 No.. 2	
909e	Was your family disturbed because of this incidence ? **IF YES** how much?	Seriously... 1 Somewhat.. 2 Not that much.................................. 3 No.. 4	
910.	How do you rate the security condition of this area (community/neighborhood)?	Very Safe... 1 Somewhat safe................................. 2 Unsafe .... 3 Very unsafe 4	
911.	Do you feel safe walking alone in daytime in this community?	Yes.. 1 No.. 2	
911a.	Do you feel safe walking at night in this community?	Yes.. 1 No.. 2	
912.	**Finishing time:**	**Hour** ☐☐ **Minute** ☐☐	

Annexure 2.2

Table 2. 8: Role of SES explaining the association between migration status and CVD risk factors

OR	SES	Obesity	hypertension	Diabetes	Mental Health Disorder	Cigarette smoking	Bidi smoking	Alcohol intake
				Men				
Crude	Urban	Ref	Ref	Ref	Ref	Ref	Ref	Ref
	Migrant	0.66 (0.59-0.74)	0.88 (0.70-1.11)	0.98 (0.68-1.44)	1.17 (1.07-1.27)	0.97 (0.90-1.03)	1.99 (1.76-2.27)	0.61 (0.55-0.68)
Stratum specific	**Education**							
	Illiterate to Primary	0.64 (0.51-0.79)	0.88 (0.62-1.24)	1.05 (0.49-2.26)	1.05 (0.93-1.78)	1.11 (0.99-1.22)	1.60 (1.38-1.85)	0.62 (0.54-0.72)
	High school and above	0.83 (0.72-0.95)	1.02 (0.75-1.39)	1.17 (0.75-1.81)	1.10 (0.96-1.26)	0.75 (0.68-0.82)	1.79 (1.31-2.45)	0.53 (0.45-0.63)
Adjusted	M-H OR	0.77 (0.68-0.87)	0.95 (0.76-1.20)	1.14 (0.78-1.67)	1.07 (0.98-1.17)	0.89 (0.84-0.96)	1.64 (1.44-1.86)	0.58 (0.52-0.65)
	% Change	16%	8%	16%	8%	7%	18%	5%
Stratum specific	**HH Wealth Quintile**							
	Q1 & Q2	0.71 (0.55-0.93)	1.32 (0.82-2.12)	1.41 (0.49-4.02)	0.99 (0.88-1.13)	0.94 (0.84-1.04)	1.65 (1.42-1.91)	0.59 (0.51-0.69)
	Q3 &Q4	0.79 (0.66-0.93)	0.88 (0.62-1.24)	0.98 (0.53-1.80)	1.11 (0.96-1.30)	0.92 (0.83-1.03)	1.17 (0.86-1.59)	0.55 (0.45-0.66)
	Q5	1.10 (0.88-1.38)	0.99 (0.64-1.52)	1.21 (0.69-2.13)	1.09 (0.83-1.43)	0.71 (0.60-0.85)	2.39 (0.53-10.71)	0.59 (0.44-0.79)
Adjusted	M-H OR	0.85 (0.75-0.96)	1.01 (0.80-1.27)	1.13 (0.77-1.67)	1.05 (0.96-1.14)	0.89 (0.84-0.96)	1.55 (1.36-1.77)	0.58 (0.52-0.64)
	% Change	28%	14%	15%	10%	8%	22%	6%
				Women				
Crude	Urban	Ref	Ref	Ref	Ref	Ref	Ref	Ref
	Migrant	0.66 (0.60-0.73)	0.77 (0.61-0.97)	0.73 (0.51-1.07)	1.14 (1.06-1.22)		-	
Stratum specific	**Education**							
	Illiterate to Primary	0.63 (0.55-0.73)	0.82 (0.61-1.09)	0.75 (0.44-1.28)	1.03 (0.94-1.12)		-	
	High school and above	0.89 (0.77-1.03)	0.93 (0.83-1.04)	0.92 (0.53-1.59)	0.97 (0.86-1.09)			
Adjusted	M-H OR	0.74 (0.67-0.82)	0.82 (0.65-1.04)	0.83 (0.57-1.22)	1.01 (0.94-1.08)			
	% Change	12%	6%	13%	11%		-	
Stratum specific	**HH Wealth Quintile**							
	Q1 & Q2	0.70 (0.58-0.85)	0.84 (0.52-1.35)	3.21 (0.40-25.71)	1.01 (0.91-1.21)			
	Q3 &Q4	0.93 (0.79-110)	1.14 (0.78-1.66)	0.95 (0.49-1.83)	1.03 (0.92-1.16)		-	
	Q5	1.01 (0.81-1.27)	0.81 (0.53-1.23)	0.94 (0.56-1.57)	1.08 (0.89-1.31)			
Adjusted	M-H OR	0.87 (0.78-0.97)	0.94 (0.74-1.20)	1.01 (0.68-1.49)	1.03 (0.96-1.10)			
	% Change	32%	44%	37%	10%		-	

Annexure 3b.1

Validity of PYPAQ

Table 3b.3 shows results relating to the concurrent validity between PYPAQ and GPAQ. The Spearman's correlation coefficient between PYPAQ and GPAQ total MVPA was 0.42, indicating moderate correlation between the questionnaires. Stratification by place of residence revealed good correlations for urban residents for total MVPA (ρ = 0.61) and MVPA travel (ρ = 0.67) and work (ρ = 0.56) but no association for leisure time (ρ = 0.05). Among rural residents the correlation coefficients for the association between PYPAQ and GPAQ for total MVPA and work, travel and leisure time MVPAs were 0.34, 0.33, 0.47 and 0.26 respectively, suggesting modest correlation between the PYPAQ and GPAQ. The median difference in MVPA MET-min/week between PYPAQ and GPAQ was 1020.0 (quartiles: -1148.5; 2833.3) for the total sample, -450.5 (-3021; 528.3) for urban and 2381.5 (547.8; 3800.8) for rural (Data not shown).

Table 3b.4 shows results related to the construct validity of PYPAQ. This Table lists the correlation coefficients of PYPAQ and its domains with weight, BMI, waist circumference, waist: hip ratio, SBP, DBP, and TG. Total MVPA showed a statistically significant inverse association with weight (ρ = -0.2) and waist circumference (ρ = -0.3). Waist circumference also showed significant associations with two of the domain specific MVPAs; travel (ρ = -0.28) and leisure time (ρ = -0.3). For total sample the domain specific inverse correlations across all anthropometric indicators except waist: hip ratios were fair for the leisure time and the travel domains.

Table 3b. 3: Concurrent validity between GPAQ and PYPAQ

GPAQ MVPA MET-min/week		PYPAQ MVPA MET-min/week					
		Total MVPA	Occupation related MVPA	Travel-related MVPA	HH-related MVPA	Leisure time MVPA	Gardening-related MVPA
All	**Total MVPA**	0.419**	0.388**	0.415**	0.075	0.204**	0.068
	Work-related activities	0.419**	0.477**	0.290**	0.139	0.079	0.171*
	Travel-related activity	0.334**	0.227**	0.510**	-0.021	0.322**	-0.113
	Leisure-time activities	0.205**	0.119	0.184*	0.162*	0.184	0.025
Urban	**Total MVPA**	0.607**	0.436**	0.543**	0.225	-0.047	0.111
	Work-related activities	0.556**	0.561**	0.329**	0.117	-0.168	0.215
	Travel-related activity	0.357**	0.162	0.672**	0.054	0.022	-0.058
	Leisure-time activities	0.352**	0.095	0.309*	0.337**	0.052	-0.057
Rural	**Total MVPA**	0.388**	0.308**	0.437**	-0.118	0.334**	0.035
	Work-related activities	0.320**	0.329**	0.178	0.020	0.049	0.135
	Travel-related activity	0.262**	0.241*	0.473**	-0.264**	0.440**	-0.186
	Leisure-time activities	0.159	0.127	0.118	0.038	0.259*	0.041

*Spearman rank correlation was performed *Statistically significantly different from 0 at $p< 0.05$ ** Statistically significantly different from 0 at $p<0.01$*

Table 3b. 4: Construct validity of PYPAQ with various health outcome

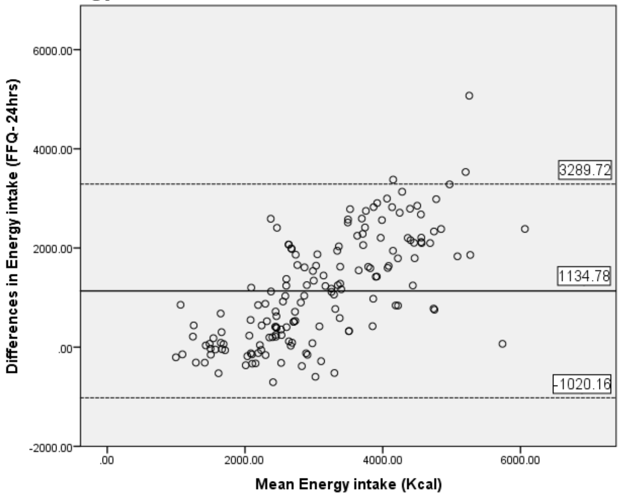
PYPAQ MET-min/week		Weight	Waist Circumference	BMI	SBP	DBP	TG	W:H ratio
All	**Total MVPA**	-0.177*	-0.263**	-0.143	0.050	-0.063	0.140	0.061
	Occupation related MVPA	-0.053	-0.148	-0.069	0.091	-0.010	0.125	-0.039
	Travel-related MVPA	-0.120	-0.280**	-0.172*	0.104	-0.015	0.203**	0.095
	HH-related MVPA	-0.220**	-0.083	-0.018	-0.084	-0.218**	-0.037	0.134
	Leisure time MVPA	-0.038	-0.316**	-0.018	-0.264**	0.118	0.246**	0.199*
	Gardening- related MVPA	-0.170*	-0.075	-0.092	-0.012	-0.095	-0.100	0.202**
Urban	**Total MVPA**	-0.136	-0.042	0.086	-0.106	-0.213	-0.041	-0.250**
	Occupation related MVPA	-0.068	-0.005	-0.010	0.111	-0.112	0.125	-0.096
	Travel-related MVPA	-0.081	0.085	0.087	-0.063	-0.120	-0.063	-0.005
	HH-related MVPA	-0.277*	-0.250*	-0.020	-0.190	-0.198	-0.229	-0.363**
	Leisure time MVPA	0.136	-0.089	-0.020	0.139	0.248	-0.041	-0.012
	Gardening- related MVPA	-0.052	-0.016	-0.099	-0.054	-0.213	-0.052	-0.017
Rural	**Total MVPA**	0.016	-0.229*	-0.054	-0.104	0.062	0.029	-0.279**
	Occupation related MVPA	0.051	-0.167	-0.028	-0.026	0.118	0.047	-0.252*
	Travel-related MVPA	0.035	-0.367**	-0.194	0.0001	0.128	0.199	-0.315**
	HH-related MVPA	-0.056	0.168	0.195	-0.216*	-0.187	-0.168	0.044
	Leisure time MVPA	0.207	-0.258*	0.195	0.214*	-0.291*	0.288**	-0.130
	Gardening- related MVPA	-0.148	-0.012	-0.026	-0.098	-0.038	-0.217*	0.112

*Spearman rank correlation was performed *statistically significantly different from 0 at p< 0.05 ** statistically significantly different from 0 at p<0.01*

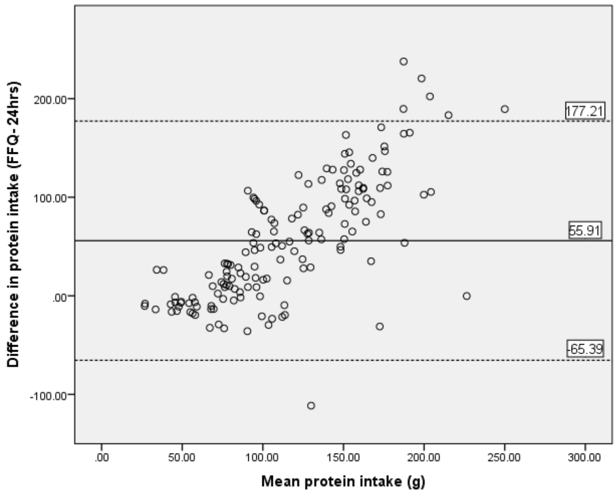
Annexure 3c.1

Supplementary file

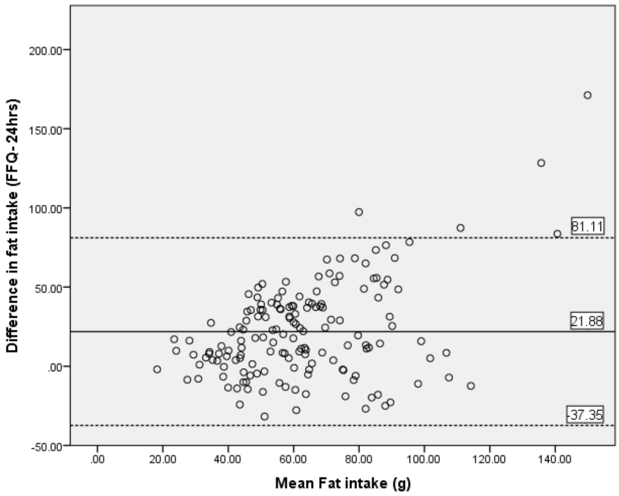
a. Energy



b. Protein



c. Fat



d. Carbohydrate

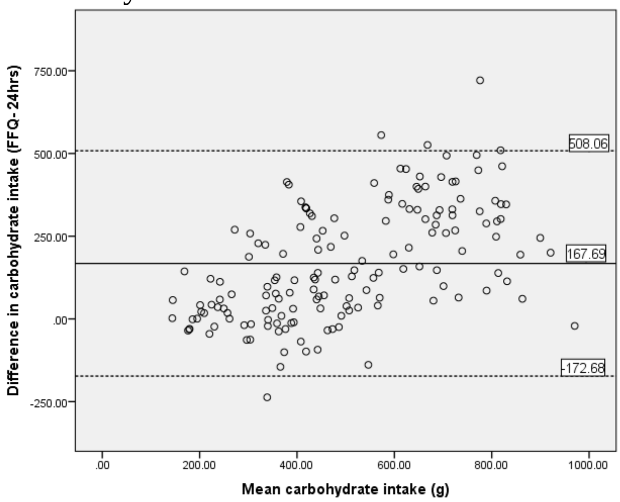
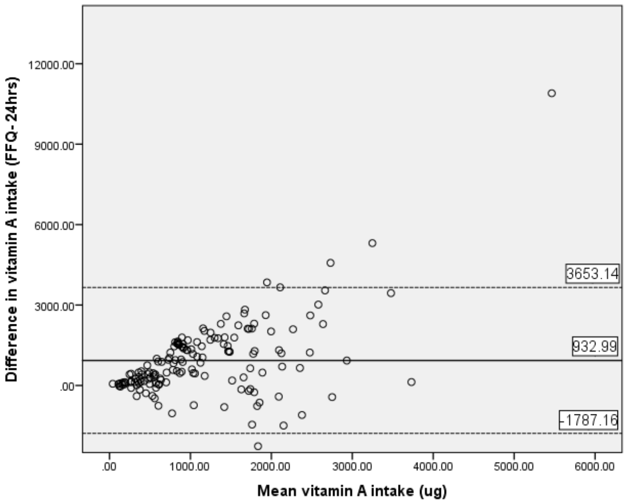
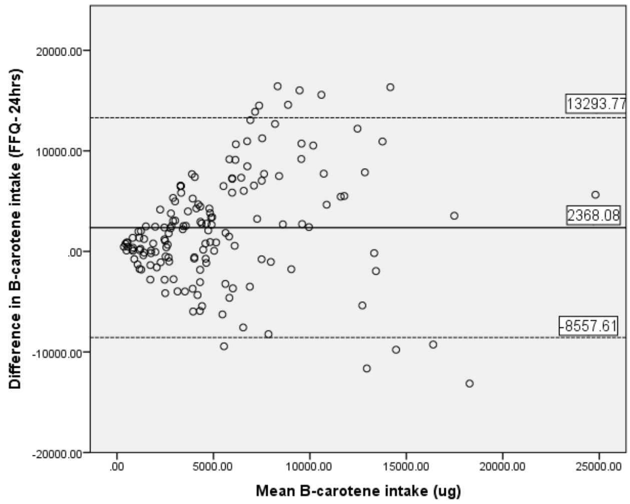


Figure 3c. 2: Bland & Altman plot of energy and macronutrient from FFQ and average of 24-hour

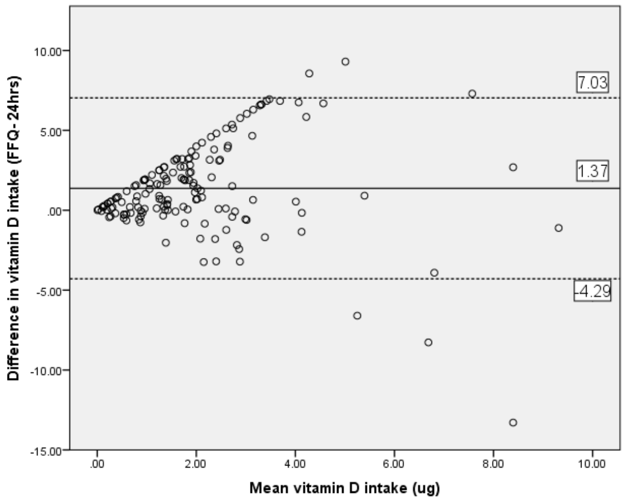
a. Vitamin A



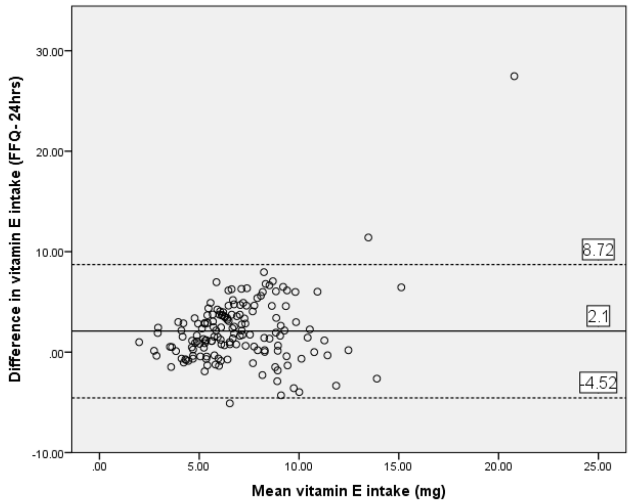
b. β-carotene



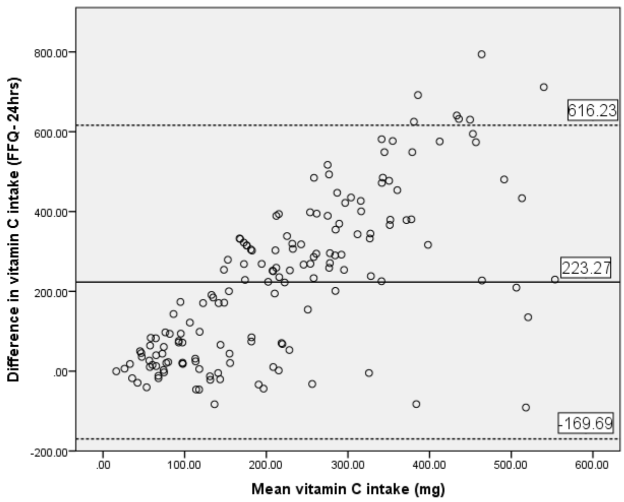
c. Vitamin D



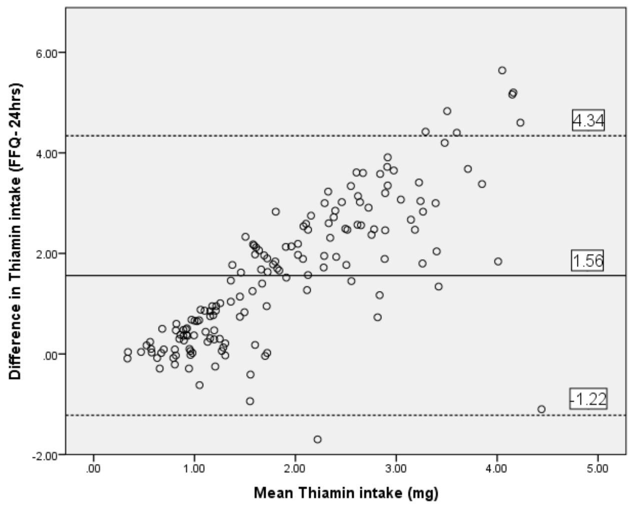
d. Vitamin E



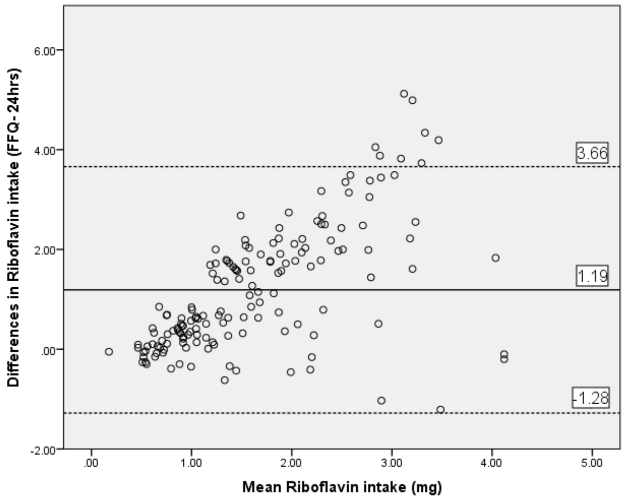
e. Vitamin C



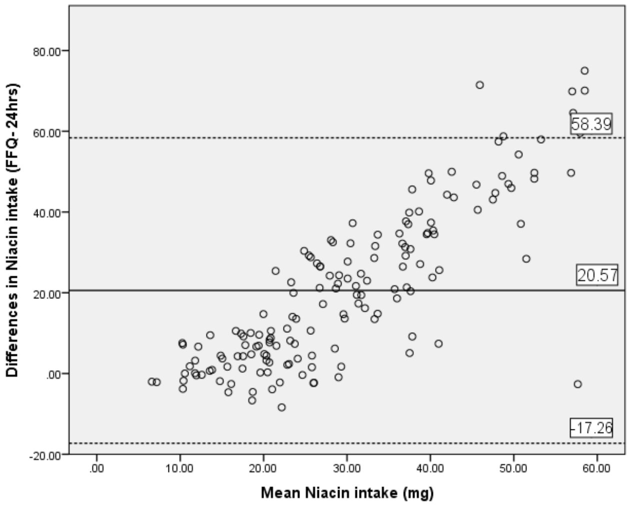
f. Thiamine



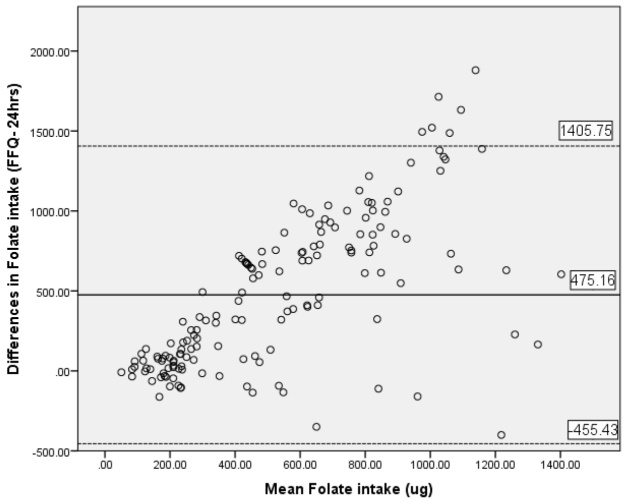
g. Riboflavin



h. Niacin



i. Folate



j. Pyrodixine

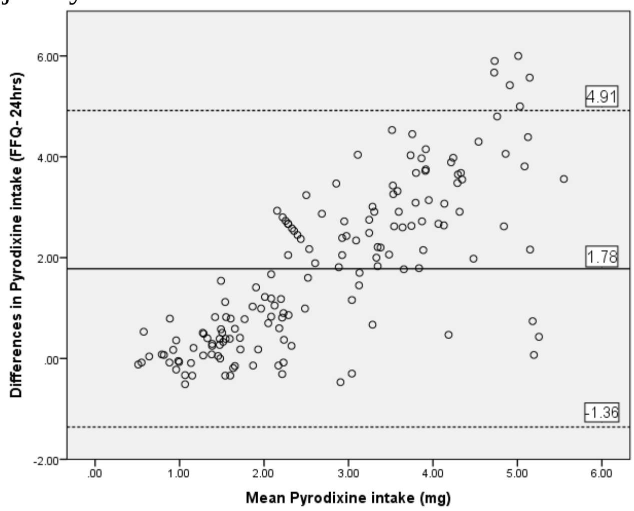
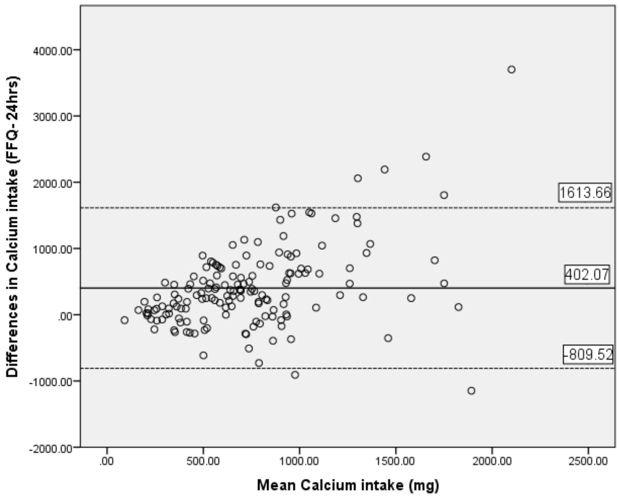
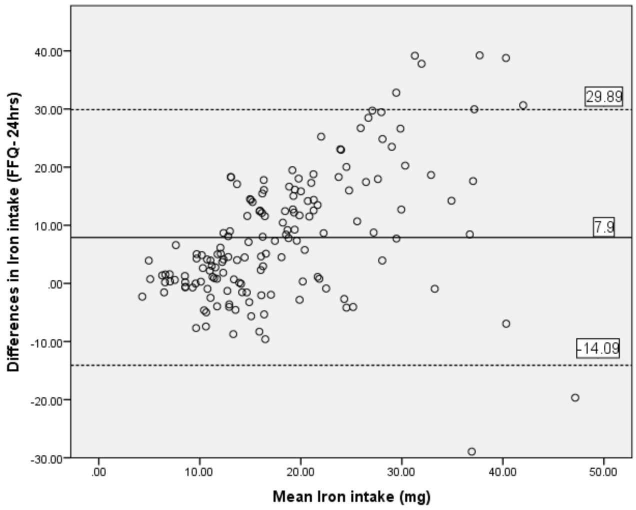


Figure 3c. 3: Bland & Altman plot of vitamin intake from FFQ and average of 24-hour

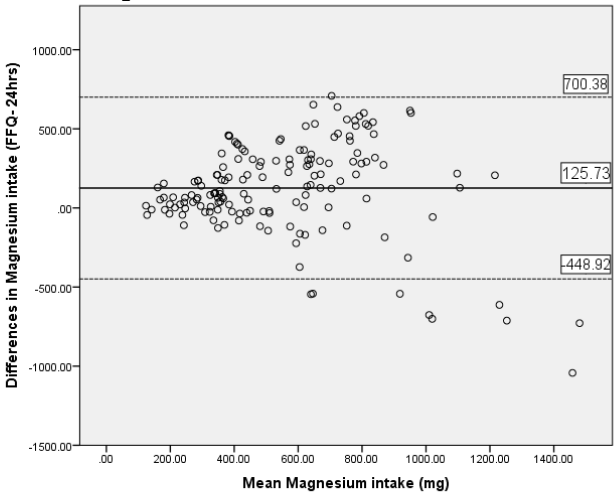
a. Calcium



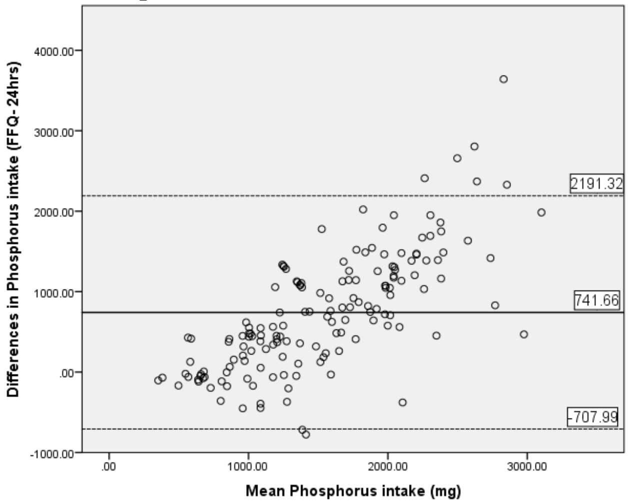
b. Iron



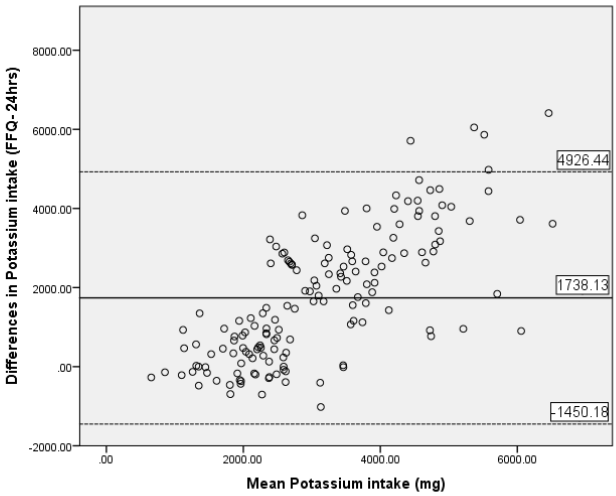
c. Magnesium



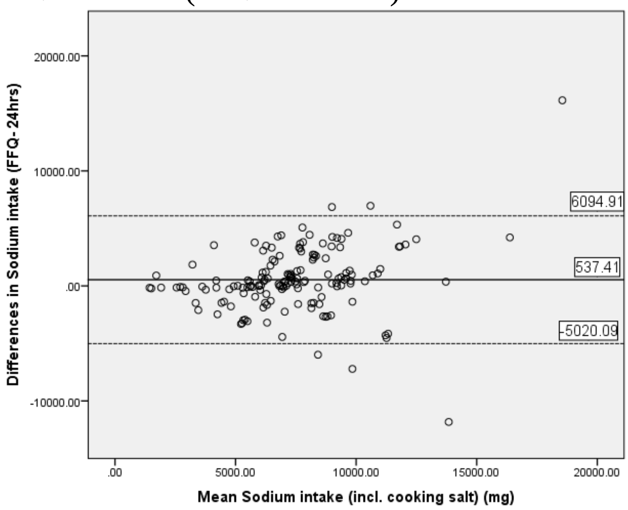
d. Phosphorus



e. Potassium



f. Sodium (incl. salt intake)



g. Sodium h. Zinc

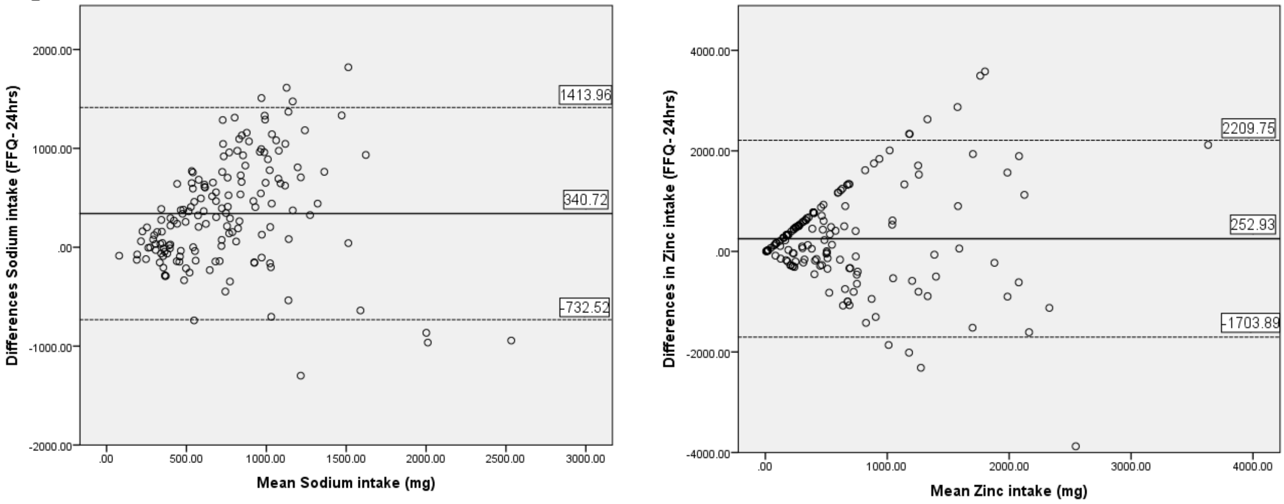


Figure 3c. 4: Bland & Altman plot of mineral intake from FFQ and average of 24-hour

Annexure 4.1

Details of study area- Pirganj (10 unions and their villages/mouzas)

Administrative Unit	Total Household	Total Population	Administrative Unit	Total Household	Total Population
No. 1 Bhomradaha Union Total	**5387**	**22563**	**No. 2 Kusha Raniganj Union Total**	**5173**	**21946**
Bhomradaha	1474	6176	Akasil	421	1710
Dubra	79	313	Arazi Alampur	173	742
Ghora Dhap	183	679	Bagar Deha	324	1222
Kachna Bil	18	80	Betura	144	564
Khamar Senua	699	2997	Bhamda	314	1368
Kusarigaon	650	2678	Choprabari	94	528
Radhikapur	291	1208	Dalapatipur	219	828
Sinuya	876	3721	Ghughua	296	1174
Tarala	125	574	Garura	362	1581
Jangaon	992	4137	Kachan Dumuria	333	1424
No. 3 Khangaon Union Total	**20985**	**20985**	Kismat Dalapatipur	254	1037
Arazi Ujalkota	168	625	Kusa	868	3906
Atargaon	221	878	Raghabpur	154	669
Banbari	315	1353	Ramdedpur	401	1751
Biswaspur	195	841	Salgara	269	1119
Chandgaon	201	738	Setrai	110	428
Chandpur	649	2737	**No. 5 Saidpur Union Total**	**5167**	**20934**
Chanpa Para	279	1146	Basantapur	262	1122
Ghidob	623	2588	Begunbari	172	664
Habibpur	185	791	Bhabanipur	488	1990
Jasai Para	600	2486	Bhadua	124	507
Khangaon	553	2443	Deona Para	81	323
Kismat Ujjalkota	45	188	Ektiarpur	226	920
Nakful	101	437	Harita	227	982
Rangalikura	71	323	Inuya	169	658
Shimulbari	293	1177	Jukti Para	58	242

Shyampur	138	624	Kanthalbari	86	260
Ujjalkota	236	969	Kismat Saidpur	501	2116
No. 6 Pirganj Union Total	**4485**	**18720**	Kota Para	578	2292
Begungaon	471	1922	Majkhuria	294	1175
Bhakura (Part-B)	471	2093	Nodhabari	91	313
Bhelatair (Part-B)	472	1886	Panihata	90	348
Bhimtia	285	1160	Shibpur	195	771
Birahali	555	2265	Surjyapur	360	1449
Bish Mail	229	1031	Thumnia	461	1960
Chandipur	266	1142	Uttar Madhabpur	225	851
Chapar	274	1112	**No. 7 Hajipur Union Total**	**5801**	**24267**
Durgapur	187	820	Bad Nohali	71	315
Gargaon	217	918	Bahara	143	574
Machhlandapur	198	830	Baje Ekannapur	66	282
Narayanpur	614	2525	Bhebra	447	1875
Paria	141	593	Chhota Maheshpur	30	133
Payandhya	105	423	Dihanagar	195	757
No. 8 Daulatpur Union Total	**4093**	**16538**	Ekannapur	496	1946
Banshgara	423	1742	Hajipur	116	486
Banuya Para	114	439	Khamar Narayanpur	744	744
Bothpaligaon(Part)	23	112	Khat Singa	1016	1016
Bishnupur	292	1194	Khidra Gargaon	1000	1000
Chak Basudebpur	51	228	Krishnapur	1165	1165
Daulatpur	325	1320	Lakhipur	84	84
Joykrishnapur	303	1221	Mahammadpur	432	432
Joykur	232	931	Malgaon	1203	1203
Kastar	420	1587	Patua Para	2870	2870
Keutgaon	289	1118	Ratan	401	401
Mallikpur	755	3188	Sasor	1020	1020
Nanuhar	185	797	Satia	2486	2486
Purba Hajipur	76	294	Shibrambati	40	40

Saguni	322	1284	Sindagar	1382	1382
Sindhula	100	376	Singarol	1942	1942
Uttar Noapara	183	707	Karna	513	2114
No. 9 Sengaon Union Total	**5058**	**21634**	**No. 10 Jabarhat Union Total**	**25583**	**25583**
Agra Garinabari	444	1931	Ananta Para	218	218
Bandanga	257	1068	Barabari	2246	2246
Basandi	337	1425	Bondiara	2369	2369
Beldahi	476	2016	Bridhigaon	1651	1651
Belsua	102	447	Chandaria	2919	2919
Danajpur	336	1375	Chandra	121	121
Danga Para	9	52	Dakshin Malancha	1714	1714
Dastampur	772	3247	Golandagaon	397	397
Deodha	173	768	Hatpara	2167	2167
Harsua	281	1226	Jabarhat	3231	3231
Kanari	240	1161	Kalijug	1361	1361
Nohali	480	1911	Karnai	3526	3526
Sengaon	326	1443	Mahadebpur	149	149
Sindurna	486	2117	Matiani	1457	1457
Updail	339	1447	Ransia	1837	1837
			Setra Para	220	220
No. 11 Bairchuna Union Total	**5427**	**22665**	**No. 11 Bairchuna Union Total**	**5427**	**22665**
Ajlabad	366	1609	Maheshpur	137	585
Bairchuna	1037	4247	Mohanpur	120	486
Beldanga	27	106	Naodanga	603	2527
Dakshin Madhabpur	293	1222	Nawadangi	52	228
Dakshin Noapara	343	1485	Ramna Chandahar	422	1704
Dopail	137	598	Salya Para Bhabanipur	188	739
Gilabari	116	507	Sataha	107	405
Indrail	388	1612	Singair	115	504
Jagannathpur	487	2019	Sirail	332	1406
Kumaria	157	676			

Source: Bangladesh Population and Housing Census 2011

Annexure 4.2

Questionnaire

(English Version)

Lifestyle risk factors and their impact on metabolic markers of cardiovascular diseases in rural-to-urban migrants compared with their non-migrant siblings

Patient ID no. | | | | |

Instructions:

- Please encircle the answers and mention the code number in 3rd column or write if necessary.
- Follow the instructions (go to question number _______or skip questions) given below in certain questions.
- Please write clearly and check for the completeness of the questionnaire at the end of interview.

Name of interviewer: ___________________________ Date: ___ / ___ / ________
DD / MM / YEAR

Time of interview: Start time ___________am/pm. End time: ___________am/pm

Participant group:

1. Migrant ☐ 2.Rural ☐

Section A: General Information

Q/no.	Questions	Answer
A1	What is your name?	…………………………………………………………………
A2	Where do you live (address)?	………………………………………………………………… …………………………………………………………………
A3	What is your phone no	…………………………………………………………………
A4	What is your email address (if present)	…………………………………………………………………
A5	National ID No.	…………………………………………………………………

Section B: Socio-demographic and economic information

Q/no.	Questions	Code	Answer
B1	What is your date of birth		………./………../………. (Day) (Month) (Year)
B2	What is your age?	Age in completed years	☐☐
B3	Sex?(by observation)	0.Male 1.Female	☐
B4	Which religion do you practice?	0. Islam 1.Buddhism 2.Hinduism 3.Christianity 88.Other (specify)……………….. 99. Refused	☐☐
B5	What is your current marital status?	0.Unmarried 1.Married 2.Widow/widower 3.Seperated/divorced 99. Refused	☐

Q/no.	Questions	Code	Answer
B6	Which level of education have you completed?	0.Illitetrate (go to Q B8) 1.Formal/institutional 2. Non-formal (go to Q B8) 99. Refused	☐☐
B7	How many years have you studied?	Completed years of education 99. Refused	…………….
B8	Which types of family are you belong to?	0.Nuclear 1.Joint 99. Refused	☐
B9	How many persons live with you as a family member including yourself?	In number 99. Refused	……………..
B10	In the last 6 months what was your main job?	0.Unemployed 1.House wife 2.Farmer 3.Service holder (desk job) 4.Retired 5.Student 6.Day laborer 7. Business (specify)…………… 88.Other (specify)………………	☐☐
B11	What was your last monthly income?	In Bangladeshi Taka 99. Refused	………………
B12	What is your yearly family income	In Bangladeshi Taka 99. Refused	………………
B14	In which income category your family income fall (In Bangladeshi Taka)?	0. <4999 1. 5000-7999 2. 8000-14999 3. 15000+ 99. Refused	☐☐
B15	What type of house do you live in?	0. Kuccha (made by soil) 1. Tin shed 2. Brick build 99. Refused	☐
B16	Do you have ownership of your house?	0. Owned 1. Rented 2. Official residence 88. Others(specify)………… 99. Refused	☐☐
B17	How many rooms does your household occupy? (excluding rooms used for kitchen, bathroom and stores)	Total number of rooms 99. Refused	☐☐
B18	Do you own cultivable agricultural land?	0. No (go to Q B18) 1. Yes 99. Refused	☐
B19	If yes what is the size of the land?	Land in decimal/sq meter/kantha 99. Refused	☐☐☐

Q/no.	Questions		Code	Answer
B20	Do you have/own any of following in your house? (If 'yes' please specify numbers)			
	i.	Electricity	0. No 1. Yes	☐
	ii	Television	0. No 0. Yes	☐ ……….
	iii	Refrigerator	0. No 1. Yes	☐ ………..
	iv	Computer/ laptop	0. No 1. Yes	☐ ………..
	v	Air Conditioner	0. No 1. Yes	☐ ………..
	vi	Microwave Oven	0. No 1. Yes	☐ ………..
	vii	Washing Machine	0. No 1. Yes	☐ …………
	viii	IPS/Generator	0. No 1. Yes	☐ ………....
	ix	Bicycle	0. No 1. Yes	☐ …………
	x	Car/ Motor Cycle	0. No 1. Yes	☐ …………
	xi	Radio	0. No 1. Yes	☐ …………
	xii	Telephone	0. No 1. Yes	☐ …………
	xiii	Mobile phone	0. No 1. Yes	☐ …………
	xiv	Sewing machine	0. No 1. Yes	☐ …………
	xv	Flash toilet	0. No 1. Yes	☐ …………

Section C: Family History of Diseases

Q/no.	Questions	Code	Answer
C1	What are the diseases your family members have?	…………………………………… ………….. 88. Don't Know 99. Refused	
C2	Does any member of your family have heart disease?	0. No (go to Q C4) 1. Yes 88. Don't Know 99. Refused	☐
C3	If Yes then, Who? (More than one answer can be taken)	0. Mother 1. Father 2. Brother 3. Sister 4. Grandfather 5. Grandmother 6. Uncle 7. Aunt 8. Others, (specify)………	☐
C4	Does any member of your family have diabetes?	0. No (go to Q C6) 1. Yes 88. Don't Know 99. Refused	☐
C5	If Yes then, Who? (More than one answer can be taken)	0. Mother 1. Father 2. Brother 3. Sister 4. Grandfather 5. Grandmother 6. Uncle 7. Aunt 8. Others, (specify)………	☐
C6	Does any member of your family have high blood pressure?	0. No (go to section D) 1. Yes 88. Don't Know 99. Refused	☐
C7	If Yes then, Who? (More than one answer can be taken)	0. Mother 1. Father 2. Brother 3. Sister 4. Grandfather 5. Grandmother 6. Uncle 7. Aunt 8. Others, (specify)………	☐

Section D: Lifestyle Related Information

Q/no.	Questions	Code	Answer
DA. Smoking			
DA1	Do you smoke? Such as Cigarette, Bidi, Hookah, Cigar, Pipe.	1. Never, (go to Q DB1) 2. Current smoker (Regularly) 3. Past smoker (Who are past smoker and left at least for 3 months) 4. Sometimes 99. Refused	
DA2	At what age did you start smoking?	At the age of ………………..	
DA3	If you are a past smoker, when have you stopped smoking?	At the age of ………………..	
DA4	What do/did you smoke?	1. Cigarette 2. Bidi 3. Cigar 4. Others, specify………. 99. Refused	
DA5	On average, how many sticks do/did you smoke every day?	No. …………...	
DB. Smokeless tobacco			
DB1	Do/did you use any smokeless tobacco? (Eg- jarda, white-leaf, gul, snuff)	1. Never, (go to Q DB2) 2. Currently (Regularly) 3. Past smoker (Who are past smoker and left at least for 3 months) 99. Refused	
DB2	What type of smokeless tobacco do/did you use?	1. jarda 2. gula 3. white-leaf 4. snuff 5. Others.....................	
DB3	How long do/did you use smokeless tobacco like jarda, white-leaf, gula, snuff?	.... Year ....Month	
DC. Drinking			
DC1	Have you ever been drinking alcoholic beverages? (Eg- local wine, beer, wine, spirits)	1. Never 2. Current drinker 3. Past drinker (who drunk in past and left at least for 3 months) 4. Sometimes	
DC2	What kind of alcoholic beverage do you usually drink?	1. local wine 2. beer 3. wine 4. spirits 5. Others..	
DC3	At what age did you start drinking alcohol first?	At the age of ………………..	
DC4	If you used to drink in the past, when have you stopped drinking alcohol?	At the age of ………………..	
DC5	If you currently drink, how many times have you drank in the last 7 days? (Eg- local wine, beer, wine, spirits)	...........................Times	
DC6	Generally, how much alcohol do you drink every time?	…………………………..ml/ .... Cans/ .... glass	

Section E: Food Frequency Questionnaire

Sl No	Food items	time/ day	times/ wk	times/ month	time /3 month	Never	Serving Size	Cooking method	No. of Participant's serving
A	**Cereals & gains**								
1	Rice						1 plate		
2	Roti/ wraps/ chapati						Small No…….. (show model) Medium No……..		
3	Paratha						Small No…….. (show model) Medium No……..		
4	Bread						1 slice		
5	Polao						1 plate		
6	Khichuri						1 plate		
7	Rice Flaked (chira)						1 cup		
8	Puffed Rice (muri)						1 cup		
9	Semolina (suji)						1 tb spoon		
10	Vermicelli (semi)						1 tb spoon		
11	Birani						1 plate		
	Others								

Sl No	Food items	time/ day	times/ wk	times/ month	time /3 month	Never	Serving Size	Cooking method	No. of Participant's serving
B	**Pulses and Legumes**								
1	Lentils (mosur dal)						1 *dal* spoon		
2	Green Gram (mung dal)						1 *dal* spoon		
3	Black gram (maskalai dal)						1 *dal* spoon		
4	Bengal gram (cholar dal)						1 table spoon		
5	Peas dried (motor dal)						1 *dal* spoon		
6	Grass pea (khesari dal)						1 *dal* spoon		
	Others								
C	**Milk/Milk Products Milk Products**								
1	Whole Milk (cow)						1 glass		
2	Skim milk (cow)						1 glass		
3	Milk powder						1 tb spoon		
4	Butter						1 tea spoon		
5	Cheese						1 tea spoon		
6	Curd						1 tb spoon		
7	Milk fat						1 tea spoon		
	Others								

Sl No	Food items	time/ day	times/ wk	times/ month	time /3 month	Never	Serving Size	Cooking method	No. of Participant's serving
D	**Meat/ Egg**								
1	Beef	1 medium piece					1 Small piece…… (show model) 1 Medium piece ………. 1 Big piece ……… ……		
2	Mutton	"					1 Small piece…… (show model) 1 Medium piece ………. 1 Big piece ……… ……		
3	Chicken	"					1 Small piece…… (show model) 1 Medium piece ………. 1 Big piece ……… ……		
4	Liver (beef/mutton)	"					1 tb spoon		
5	Cow/goat brain						1 tb spoon		
6	Hen Egg						1 piece		
7	Duck Egg	"					1 piece		
8	Koel Egg	"					1 piece		
9	Cow's intestine *(Vuri)*								
E	**Fish**								
1	Hilsha *(Ilish)*						1 Small piece…… (show model) 1 Medium piece ………. 1 Big piece ……… ……		
2	Dragon fish *(Pangash)*						1 Small piece…… (show model) 1 Medium piece ………. 1 Big piece ……… ……		
3	Rohu *(Rui)*						1 Small piece…… (show model) 1 Medium piece ………. 1 Big piece ……… ……		
4	Catla *(Katla)*						1 Small piece…… (show model) 1 Medium piece ………. 1 Big piece ……… ……		

Sl no	Food items	time/ day	times/ wk	times/ month	time /3 month	Never	Serving Size	Cooking method	No. of Participant's serving
5	Boal *(Boal)*						1 Small piece…… (show model) 1 Medium piece ………. 1 Big piece ……… ……		
6	Barb *(Sorpunti)*						1 whole fish….. (show model) 1 Head…….. 1 Tail……….		
7	Pool burb *(Puti)*						1 fish		
8	Climbing perch *(Koi)*	"					1 Small …… (show model) 1 Medium ………. 1 Big ……… ……		
9	Day's mystus *(Tangra)*	"					1 Small …… (show model) 1 Medium ………. 1 Big ……… ……		
10	Mola carplet *(Choto mach)*						1 table spoon		
11	Ganges river sprat *(Kachki)*	"					1 table spoon		
12	Prawns *(Gura chingri)*	"					1 table spoon		
13	Giant prwan *(Golda chingri)*						1 piece		
14	Walking catfish *(Magur)*	"					1 Small piece … (show model) 1 Big piece ………. 1 Head……… …… 1 Tail……		
15	Stinging catfish *(Shing)*	"					1 fish … (show model) 1 Head……… …… 1 Tail……		
16	Tilapia *(Telapia)*						1 fish … (show model) 1 Head……… …… 1 Tail……		

Sl no	Food items	time/ day	times/ wk	times/ month	time /3 month	Never	Serving Size	Cooking method	No. of Participant's serving
17	Striped snake-head *(Shol)*						1 Small piece … (show model) 1 Big piece ………. 1 Head……… …… 1 Tail……		
18	Goby *(Bele)*						1 Small piece … (show model) 1 medium piece…. 1 Big piece ……….		
19	Indian Batashi *(Batashi)*						1 table spoon		
20	Catfish *(Pabda)*						1 Small piece … (show model) 1 Big piece ………. 1 Head……… …… 1 Tail……		
21	*Guchi* Fish						1 table spoon		
22	*Chang* Fish						1 table spoon		
23	Bigret						1 Small piece … (show model) 1 Big piece ………. 1 Head……… …… 1 Tail……		
24	Glass carp						1 Small piece … (show model) 1 Big piece ………. 1 Head……… …… 1 Tail……		
25	Silver carp						1 Small piece … (show model) 1 Big piece ………. 1 Head……… …… 1 Tail……		

Sl no	Food items	time/ day	times/ wk	times/ month	time /3 month	Never	Serving Size	Cooking method	No. of Participant's serving
26	Minar carp						1 Small piece … (show model) 1 Big piece ………. 1 Head……… …… 1 Tail……		
27	Gourami *(Kholshe)*						1 table spoon		
28	Bronze feather back *(Foli)*						1 table spoon		
29	Spiny eel fish *(Bain)*						1 table spoon		
30	Spotted snakehead *(Shati/Taki)*						1 table spoon		
31	Dry fish *(Shutki Chingri)*						1 table spoon		
32	Dry fish *(Shutki Mola)*						1 table spoon		
	Others								
F	**Green Leafy Vegetables**								
1	Indian Spinach *(Puishak)*	1 tb spoon					1 table spoon		
2	Amaranth *(Lal shak)*	"					1 table spoon		
3	Bottle ground *(Lau shak)*	"					1 table spoon		
4	Arum leaves *(Kochu shak)*	"					1 table spoon		
5	Spinach *(Palong shak)*	"					1 table spoon		
6	Water Spinach *(Kolmee shak)*	"					1 table spoon		
7	Jute plant tops *(Pat shak)*	"					1 table spoon		

Sl no	Food items	time/ day	times/ wk	times/ month	time /3 month	Never	Serving Size	Cooking method	No. of Participant's serving
8	Amaranath leaves *(Data shak)*						1 table spoon		
9	*Lafa shak*						1 table spoon		
10	*Chiramira shak*						1 table spoon		
11	Fern *(Dheki shak)*						1 table spoon		
12	Potato leaves *(Aloo shak)*						1 table spoon		
13	Watercress *(Helecha)*						1 table spoon		
14	*Sorisha shak*						1 table spoon		
	Others								
G	**Vegetables**								
1	Potato *(Aloo)*	"					1 table spoon…………. 1 small piece…….. 1 big piece……….. 1 tea spoon (mashed potato)		
2	Sweet potato *(Misti Aloo)*	"					1 table spoon		
3	Brinjal *(Begun)*	"					1 piece/ 1 tea spoon (mashed)		
4	Radish *(Mula)*	"					1 table spoon		
5	Sweet Pumpkin *(Mishti kumra)*	"					1 table spoon		
6	Gourd *(Chal kumra)*						1 table spoon		

Sl no	Food items	time/ day	times/ wk	times/ month	time /3 month	Never	Serving Size	Cooking method	No. of Participant's serving
7	Folwal *(Potol)*						1 piece/ 1 table spoon		
8	Gourd, snack *(Kaitha/chichinga)*						1 table spoon		
9	Green papaya *(Pepe)*						1 table spoon		
10	Tomato *(Tomato)*						1 tomato		
11	Gourd, bottle *(Lau)*						1 table spoon		
12	Cucumber *(Sosha)*	"					1 whole		
13	Gourd, ridge *(Jhinga/toroi)*						1 table spoon		
14	Arum *(Kochu)*						1 table spoon		
15	Colocasia *(Kochumukhi)*	"					1 table spoon		
16	Plantain *(Kacha kola)*	"					1 table spoon		
17	Ladies finger *(Dheros)*	"					1 table spoon		
18	Raw jackfruit *(Echor)*						1 table spoon		
19	Jackfruit seeds *(Kathaler bichi)*						1 table spoon		
20	Gourd, sponge *(Dhundol)*						1 table spoon		
21	Bitter gourd *(Korola)*						1 table spoon		
22	Gourd, teasle *(Kakrol)*	"					1 table spoon		
23	Bean *(Shim)*	"					1 table spoon		
24	Carrot *(Gajor)*	"					1 table spoon/ 1 whole		
25	Cow Pea *(Borboti)*	"					1 table spoon		
26	Cauliflower *(Fulkopi)*	"					1 table spoon		

Sl no	Food items	time/ day	times/ wk	times/ month	time /3 month	Never	Serving Size	Cooking method	No. of Participant's serving
27	Cabbage *(Badha kopi)*	"					1 table spoon		
28	Tanip *(Shalgom)*	"					1 table spoon		
29	Green Peas *(Motor shooti)*	"					1 table spoon		
	Others								
G	**Fruits**								
1	Coconut *(Narikel)*						1 Small piece … (show model) 1 medium piece 1 Big piece ……….		
2	Orange *(Komla)*						1 whole small ….(show model) 1 whole medium… 1 whole big……		
3	Apple *(Apel)*						1 whole….. 1 piece …(show model)		
4	Mango *(Aam)*						1 whole….. 1 piece …(show model)		
5	Jack fruit *(Kathal)*						1 piece……..		
6	Banana *(Kola)*						1 whole small ….(show model) 1 whole medium… 1 whole big……		
7	Papaya *(Paka pepe)*						1 slice		
8	Guava *(Peyara)*						1 whole small ….(show model) 1 whole medium… 1 whole big……		
9	Lychee *(Lichu)*						1 whole….		
10	Grapes *(Angur)*						1 whole…..		
Sl no	**Food items**	**time/ day**	**times/ wk**	**times/ month**	**time /3 month**	**Never**	**Serving Size**	**Cooking method**	**No. of Participant's serving**

11	Lemon *(Lebu)*						1 whole…..		
12	Hog plum *(Amra)*						1 whole…..		
13	Pomelo *(Jambura)*						1 table spoon….		
14	Jambolan *(Jam)*						1 whole…..		
15	Jujube *(Boroi)*						1 whole…..		
16	Emblic *(Amloki)*						1 whole…..		
17	Carambola *(Kamranga)*						1 whole…..		
18	Pineapple *(Anaros)*						1 piece….		
19	Watermelon *(Tormuj)*						1 piece (show model)		
20	Dates *(Khejur)*						1 whole….		
21	Pomegranate *(Anar)*						1 table spoon		
22	Malta *(Malta)*						1 whole….		
	Others								
H	**Snacks**								
1	*Singara*						1 piece		
2	*Samucha*						1 piece		
3	*Puri*						1 piece		
4	*Peyaju*						1 piece		
5	Biscuit salted						1 piece		
6	Biscuit sweet						1 piece		
7	Biscuit toasted						1 piece		
8	Noodles						1 table spoon		
9	Potato *chop*						1 piece		
I	**Fast Foods**								
1	Chicken burger						1 piece		
2	Beef burger						1 piece		
Sl no	**Food items**	**time/ day**	**times/ wk**	**times/ month**	**time /3 month**	**Never**	**Serving Size**	**Cooking method**	**No. of Participant's serving**
3	Sandwich						1 piece		

4	Chicken fry						1 piece		
5	Chicken patis						1 piece		
6	Pizza						1 piece		
7	French fry						1 piece		
	Others								
J	**Sweets**								
1	*Rosogolla*						1 piece		
2	*Chamcham*						1 piece		
3	*Chanar misti*						1 piece		
4	*Jilapi*						1 piece		
5	*Rosmalai*						1 piece		
6	Ice-cream						1 table spoon 1 ice cream		
7	Pudding						1 table spoon 1 piece		
8	*Payesh/Khir*						1 table spoon		
9	Plane cake						1 piece		
10	*Tel pitha*						1 piece		
Sl no	**Food items**	**time/ day**	**times/ wk**	**times/ month**	**time /3 month**	**Never**	**Serving Size**	**Cooking method**	**No. of Participant's serving**
12	*Gurguria*						1 piece		

13	*Nun pitha*						1 piece		
14	*Vapa pitha*						1 piece		
15	*Chitoi pitha*						1 piece		
16	*Patisapta*						1 piece		
17	*Narkel pitha*								
K	**Beverages**								
1	Tea/coffee						1 cup		
2	Cold drinks/energy drinks						1 bottle 1 glass		
3	Juice						1 glass		
L	**Oil and salt**								
1	Usually how much oil do you and your family use for cooking each month?						Soybean oil Mustard oil Sunflower Ghee Dalda Palm oil	…………………………….. litre …………………………….. litre …………………………….. litre …………………………….. kg …………………………….. kg …………………………….. litre	
2	Usually how much salt do you and your family use each month?						Packet Open	………………………………kg ………………………………kg	

Section F: Global Physical Activity Questionnaire

Next I am going to ask you about the time you spend doing different types of physical activity in a typical week. Please answer these questions even if you do not consider yourself to be a physically active person.

Think first about the time you spend doing work. Think of work as the things that you have to do such as paid or unpaid work, study/training, household chores, harvesting food/crops, fishing or hunting for food, seeking employment. *[Insert other examples if needed]*. In answering the following questions 'vigorous-intensity activities' are activities that require hard physical effort and cause large increases in breathing or heart rate, 'moderate-intensity activities' are activities that require moderate physical effort and cause small increases in breathing or heart rate.

	Questions	Response		Code
Activity at work				
1	Does your work involve vigorous-intensity activity that causes large increases in breathing or heart rate like *[carrying or lifting heavy loads, digging or construction work*] for at least 10 minutes continuously? *[INSERT EXAMPLES] (USE SHOWCARD)*	Yes No	1 2 *If No, go to P 4*	P1
2	In a typical week, on how many days do you do vigorous-intensity activities as part of your work?	Number of days	└─┘	P2
3	How much time do you spend doing vigorous-intensity activities at work on a typical day?	Hours : minutes	└─┴─┘ : └─┴─┘ hrs mins	P3 (a-b)
4	Does your work involve moderate-intensity activity that causes small increases in breathing or heart rate such as brisk walking *[or carrying light loads*] for at least 10 minutes continuously? *[INSERT EXAMPLES] (USE SHOWCARD)*	Yes No	1 2 *If No, go to P 7*	P4
5	In a typical week, on how many days do you do moderate-intensity activities as part of your work?	Number of days	└─┘	P5
6	How much time do you spend doing moderate-intensity activities at work on a typical day?	Hours : minutes	└─┴─┘ : └─┴─┘ hrs mins	P6 (a-b)

Travel to and from places				
The next questions exclude the physical activities at work that you have already mentioned. Now I would like to ask you about the usual way you travel to and from places. For example to work, for shopping, to market, to place of worship. [insert other examples if needed]				
7	Do you walk or use a bicycle (*pedal cycle*) for at least 10 minutes continuously to get to and from places?	Yes No	1 2 *If No, go to P 10*	P7
8	In a typical week, on how many days do you walk or bicycle for at least 10 minutes continuously to get to and from places?	Number of days	└─┘	P8
9	How much time do you spend walking or bicycling for travel on a typical day?	Hours : minutes	└─┴─┘ : └─┴─┘ hrs mins	P9 (a-b)
Recreational activities				
The next questions exclude the work and transport activities that you have already mentioned. Now I would like to ask you about sports, fitness and recreational activities (leisure), [insert relevant terms].				
10	Do you do any vigorous-intensity sports, fitness or recreational (*leisure*) activities that cause large increases in breathing or heart rate like [*running or football,]* for at least 10 minutes continuously? *[INSERT EXAMPLES] (USE SHOWCARD)*	Yes No	1 2 *If No, go to P 13*	P10
11	In a typical week, on how many days do you do vigorous-intensity sports, fitness or recreational (*leisure*) activities?	Number of days	└─┘	P11
12	How much time do you spend doing vigorous-intensity sports, fitness or recreational activities on a typical day?	Hours : minutes	└─┴─┘ : └─┴─┘ hrs mins	P12 (a-b)
13	Do you do any moderate-intensity sports, fitness or recreational *(leisure*) activities that causes a small increase in breathing or heart rate such as brisk walking,(*cycling, swimming, volleyball*)for at least 10 minutes continuously? *[INSERT EXAMPLES] (USE SHOWCARD)*	Yes No	1 2 *If No, go to P16*	P13
14	In a typical week, on how many days do you do moderate-intensity sports, fitness or recreational (*leisure*) activities?	Number of days	└─┘	P14

15	How much time do you spend doing moderate-intensity sports, fitness or recreational (*leisure*) activities on a typical day?	Hours : minutes	└─┴─┘ : └─┴─┘ hrs mins	P15 (a-b)
Sedentary behaviour				
The following question is about sitting or reclining at work, at home, getting to and from places, or with friends including time spent [sitting at a desk, sitting with friends, travelling in car, bus, train, reading, playing cards or watching television], but do not include time spent sleeping. *[INSERT EXAMPLES] (USE SHOWCARD)*				
16	How much time do you usually spend sitting or reclining on a typical day?	Hours : minutes	└─┴─┘ : └─┴─┘ hrs min s	P16 (a-b)

Section G: Overall Mental Health- Kessler 10

The next 10 questions are about how you have been feeling in the past 4 weeks. If you feel uncomfortable with any questions, just tell me and I will move on to the next questions.

	Statements	**None of the time**	**A little of the time**	**Some of the time**	**Most of the time**	**All of the time**
G1	In the past 4 weeks, about how often did you feel tired out for no good reason?					
G2	In the past 4 weeks, about how often did you feel nervous?					
G3	In the past 4 weeks, about how often did you feel so nervous that nothing could calm you down					
G4	In the past 4 weeks, about how often did you feel hopeless?					
G5	In the past 4 weeks, about how often did you feel restless or fidgety?					
G6	In the past 4 weeks, about how often did you feel so restless you could not sit still					
G7	In the past 4 weeks, about how often did you feel depressed?					
G8	In the past 4 weeks, about how often did you feel that everything was an effort?					
G9	In the past 4 weeks, about how often did you feel so sad that nothing could cheer you up?					
G10	In the past 4 weeks, about often did you feel worthless?					

Section H: Migration Related Information

(Ask only those who came from rural to urban)

Q/no.	Questions	Code		Answer
H1	Where did you born?	0. Rural 1. Urban		☐
H2	How long have you been living continuously in current place?	………..Number of years 0. Always 99. Refused		☐☐
H3	Where did you live before this?	0. Rural, specify……………. (go to G6) 1. Urban, specify………………		☐
H4	If you lived in another city before coming to Dhaka from Pirganj, where did you live?	Place	How many years were there?	
H5	For how many days			
H6	What was your age when you first migrated to an urban place?	Age in completed years 88. Other/ not migrated……… 99. Refused		☐☐
H7	What was the main reason for moving to the current place?	0.Looking for work 1. For more Earning 2. Service 3. For familial 4. For marriage 5. Buy new land/house 6. For river erosion 7. For security 88. Other, specify…………… 99. Refused		☐☐
H8	What was your education level when you first move to urban area?	0. Illiterate 1. Completed years of education 99. Refused		☐☐
H9	What was your occupation before coming to the current place?	0. Same as now 1. Different, specify……………		☐

Section I: Acculturation Related information

(Ask only those who came from rural to urban)

Q/no.	Questions	Code				Answer
	Language use					
I1	Usually, in what language communicates with your Spouse?	1. Only local dialect- Bengali 2. Mostly local dialect -Bengali 3. Both equally 4. Mosty standard Bengali 5. Only standard Bengali				☐
I2	Usually, in what language communicates with your child(ren)?	1. Only local dialect- Bengali 2. Mostly local dialect -Bengali 3. Both equally 4. Mosty standard Bengali 5. Only standard Bengali				☐
I3	Usually, in what language communicates with your Parents?	1. Only local dialect- Bengali 2. Mostly local dialect- Bengali 3. Both equally 4. Mosty standard Bengali 5. Only standard Bengali				☐
I4	Usually, in what language communicates with your Friends?	1. Only local dialect- Bengali 2. Mostly local dialect- Bengali 3. Both equally 4. Mosty standard Bengali 5. Only standard Bengali				☐
I5	What is your favorite music?	1. 0.Local music 2. 1.Another, specify………				☐
	Dietary habits					
I6	How often in your home prepare typical dishes in your area of origin or use food from the area where you born?	1. Never 2. Very little 3. Most of the time 4. Always				☐
I7	Since living in the Dhaka, you might have changed some diet habits. Please rate the following patterns comparing to the condition when you were in Pirganj	**0.More often**	**1.Same**	**2.Less often**	**3.Never**	
i	Drinking soda /Cold drinks					☐
ii.	Drinking plain water					☐
iii.	Drinking energy drinks					☐
iv.	Drinking coffee/tea					☐
v.	Eating fast food like burger, sandwich, chicken fry					☐
vi.	Eating chips/popcorn					☐
vii.	Eating processed or canned foods					☐
viii	Eating fruits					☐
ix.	Eating vegetables					☐

x.	Eating beef/mutton					☐
xi.	Eating chicken/duck					☐
xii.	Eating fish					☐
xiii	Eating out (hotel, restaurant)					☐
xiv	Eating butter/mayonnaise/cheese/ghee					☐
xv	Eating snacks which are roasted in oil like peyaju/beguni/singara/puri					☐
xvi	Taking vitamin supplement					☐
	Physical activity					
I8	As you have now come to the city, what statement do you think applies here?	0. I am far more active than the village now 1. I am more active than the village now 2. I am same active as I was in the village. 3. I am less active than the village 4. I am far less active than the village				☐

Check List

ID:

Participant name:

i. Clinical parameter

Sl No.	Blood pressure measure (sitting position)	Unit	Answer	
F1	Systolic	In mmHg	1st reading	
			2nd reading	
			3rd reading: If 1st and 2nd reading difference is more than 5 mmHg	
F2	Diastolic	In mmHg	1st reading	
			2nd reading	
			3rd reading: If 1st and 2nd reading difference is more than 5 mmHg	

ii. Anthropometry

Sl No.	Measure	Unit	Answer
F3	Height	Centimeter	☐☐☐. ☐☐
F4	Weight	Kilogram	☐☐☐. ☐☐
F5	Waist circumference	Centimeter	☐☐☐. ☐☐
F6	Hip circumference	Centimeter	☐☐☐. ☐☐

iv. Skinfold Thickness

Sl No.	Measure	Unit	Answer
F7	Bicep	mm	☐☐☐. ☐☐
F8	Tricep	mm	☐☐☐. ☐☐
F9	Subscapular	mm	☐☐☐. ☐☐
F10	Suprailiac	mm	☐☐☐. ☐☐

Annexure 4.3

GPAQ analysis guidelines and calculations

MET values for the calculation of physical activity the following MET values are used:

Domain	METS value
Work	• Moderate MET value = 4.0 • Vigorous MET value = 8.0
Transport	Cycling and walking MET value = 4.0
Recreation	• Moderate MET value = 4.0 • Vigorous MET value = 8.0

Levels of total physical activity

Level of total physical activity	Physical activity cutoff value
High	• IF:(P2 + P11) >= 3 days AND Total physical activity MET minutes per week is >= 1500 **OR** • IF: (P2 + P5 + P8 + P11 + P14) >= 7 days AND total physical activity MET minutes per week is >= 3000
Moderate	• IF: (P2 + P11) >= 3 days AND ((P2 * P3) + (P11 * P12)) >= 60 minutes **OR** • IF: (P5 + P8 + P14) >= 5 days AND ((P5 * P6) + (P8 * P9) + (P14 * P15)>= 150 minutes **OR** • IF: (P2 + P5 + P8 + P11 + P14)>= 5 days AND Total physical activity MET minutes per week >= 600
Low	If the value does not reach the criteria for either high or moderate levels of physical activity